POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, SEPTEMBER 15, 1927 No. 18

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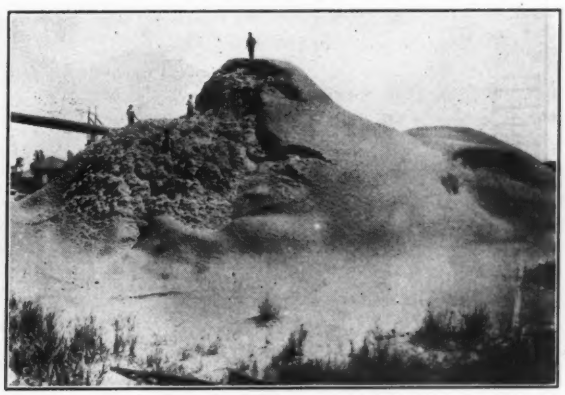


"Hey, Hiram!"

"YEAH, haow's she goin'?

"Runnin' abaout forty bushel here on the north quarter, Hiram, but pretty light on the south forty—little wet daown that way by the river this spring and besides—"

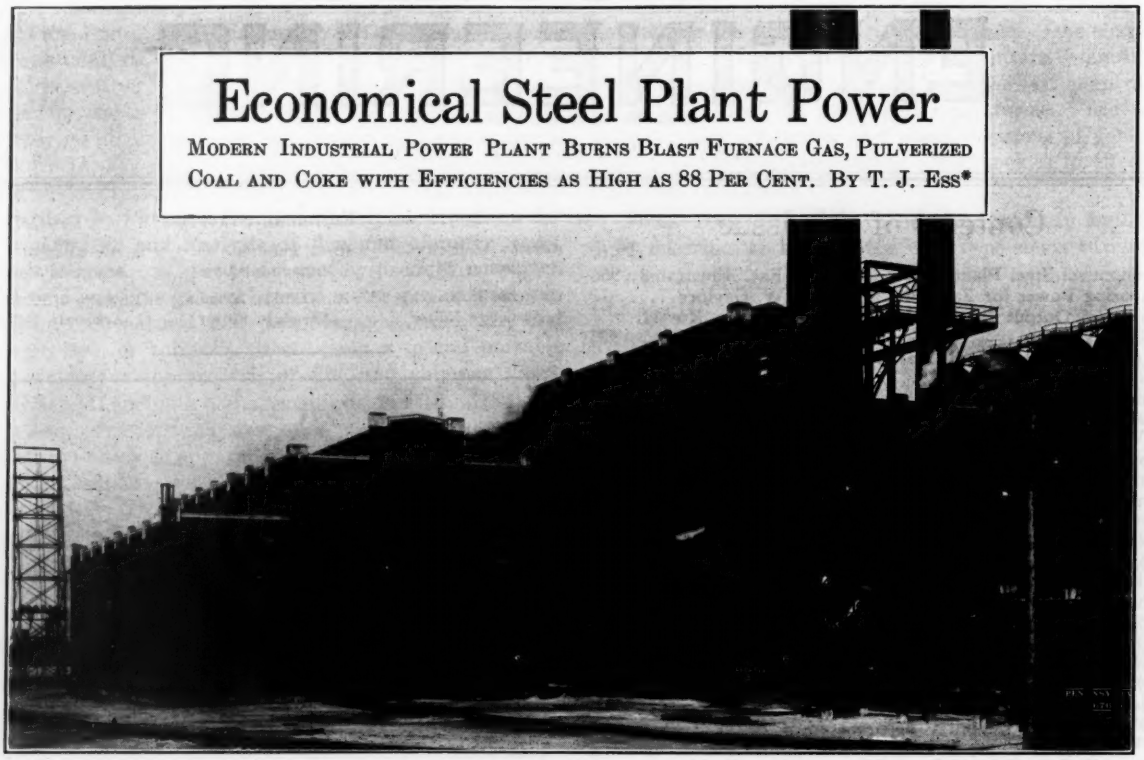
Confound it! Television operators now-a-days are just as bad as telephone operators were in the old days. She saw this picture of a supposed straw stack and connected us with Joshua Runkel's farm in Iowa. As a matter of fact, we were trying to get the S. P. C. A. to see if they could dig up some of their old records. It seems that up in Jackson two or three years ago the horse owners discovered this stack of shavings at one of the Hayes Wheel Co. plants and immediately put green goggles on the horses and led them out there to feed.

Now this might work with excelsior or pine shavings. But the Hayes Wheel Co. makes automobile wheels—furthermore, they use hickory. Either because they were hickory or because of their connection with the automobile industry, the shavings disagreed with the horses, creating somewhat of a local commotion at the time. Popular opinion laid the blame at the door of the American Society of Veterinary Surgeons and the Amalgamated Glue Works Association.

In the meantime the company had built a power house designed to burn the shavings and the horse incident has been entirely forgotten. The boiler room arrangement described by Mr. Lyons in this issue is unique. If you are in Jackson, you are invited to visit the plant. They hold open house and serve tea Saturday afternoons, but will be glad to show you through the power plant any day of the week.

Economical Steel Plant Power

MODERN INDUSTRIAL POWER PLANT BURNS BLAST FURNACE GAS, PULVERIZED COAL AND COKE WITH EFFICIENCIES AS HIGH AS 88 PER CENT. BY T. J. ESS*



IN CONNECTION with the blast furnace plant at the Massillon Works of the Central Alloy Steel Corporation was built what is reputed to be one of the most complete and modern industrial power plants in the country. This plant was built to provide facilities for supplying air to the blast furnace and to furnish power for the furnace and steel mills of the Corporation, using either the by-product fuels from the blast furnace and coke plant, or coal. The present generating capacity is 10,000 kw. but much of the auxiliary equipment was installed with a view to further expansion.

In the power house, which is a building 62 ft. by 140 ft. with a lean-to 30 ft. by 140 ft., are the two turbo-blowers supplying the blast to the furnace, one operating, with one as a spare. They employ three-stage compression, delivering normally 50,000 cu. ft. per min. at 18 lb. pressure. Operating characteristics are shown in Fig. 2. They are driven by eight-stage Curtis condensing turbines of 3950-5300 hp., designed to take steam at 275 lb. pressure and 150 deg. F. superheat. The turbines are served by condensers of 6400 sq. ft. surface, cylindrical shell standard type, two-pass, with Muntz metal tube heads to receive 2360 seamless drawn Muntz metal tubes, ¾ in. diam. by 14 ft. long, No. 18 BWG, designed to condense 55,000 lb. of steam per hour with 3 in. mercury absolute pressure when supplied with not less than 7000 g.p.m. of water at 90 deg. F. temperature.

The turbines are controlled by newly developed constant volume governors designed to maintain constant volume within 5 per cent of rate of flow regardless of resistance. The adjustment can be set to hold any volume within the range of the unit.

*Engineer, Central Alloy Steel Corp.

CLOSED AIR CIRCUIT COOLS GENERATOR

At present, one turbo-generator is installed in the power house, rated at 10,000 kw., 12,500 kv.a., 11,000 v., 3 phase, 60 cycle, 1800 r.p.m., with direct connected exciter of 75 kw., 250 v., 300 amp. capacity. The turbine has nine stages and is designed for steam at 275 lb. pressure and 150 deg. F. superheat. Water rates on the turbine are approximately as given in Fig. 4. The generator is cooled by air circulation in a closed system supplied with about 455 sq. ft. of cooling surface. Water to this air cooler is controlled by motor operated valves with control stations at the switchboard. The turbine is served by a two-pass, 14,400-sq. ft. surface condenser, containing 5000 Muntz metal tubes ¾ in. by 14 ft. 8½ in. long, No. 18 BWG, with tube layout so as to provide steam lanes to permit steam to flow to all parts of the interior with minimum resistance. It is designed to condense 125,000 lb. of steam per hour, maintaining an absolute pressure of 1½ in. mercury when supplied with not less than 16,100 g.p.m. of water at 65 deg. F. temperature. A water velocity of about 5 ft. per sec. through the tubes is obtained. Under periods of high load, the ratio of circulating water to steam condensed will go as low as 50 to 1, and a condensation rate of 11.74 lb. of steam per hr. per sq. ft. of surface is reached. Figure 5 shows the result of loads and water temperature on condenser performance.

Connected to the generator are duplicate 11,000-v. busses to which are connected the lines to the steel mills, composed of six legs of 500,000 c.m. conductor. At the steel mill this line ties in through transformers with lines from the Ohio Public Service Co., and an interchange of power is effected. This enables the plant to dispose of excess power during periods of light load, or to draw power as may be necessary, at the same time

furnishing protection against failure of the single generating unit. This plan has worked out very satisfactorily. A remote indicating meter gives the operator direct knowledge of the amount and direction of flow of power. Power for the blast furnace and coke plant is distributed from the power house at 2300 and 230 v. a.c. and 250 v. d.c., the latter being supplied by three 550 kw. synchronous converters, located together with all switchboards in the lean-to, the floor of which is raised about 8 ft. above the main power house floor.

Oil from any or all of the main units can be passed through the centrifugal oil purifier.

Each condenser is provided with a single circulating pump and duplicate hot well pumps.

All Cooling Water Must Be Softened

Water is supplied to the plant from four 24-in. wells about 120 ft. deep, from which it is pumped by three service pumps of 3500 g.p.m. capacity each. The bulk of this water is used by the furnace and coke plant, the only raw water used in the power plant being in the ash-hopper sprays. Due to the extreme hardness of the water, which averages about 28 grains of encrusting solids, all cooling water must be softened. Accordingly, the water passes through a cold continuous process treating plant, with a capacity of 60,000 gal. per hour, where it is treated with lime and alum, removing the temporary hardness and giving a water of 11 to 12 grains hardness. This water is used in the generator air cooler and oil cooler and returns to a clear well where it is given an acid treatment with a solution of niter-cake. This treatment tends to prevent any precipitation. This water is then used for make-up to the spray pond, which is 167 ft. by 375 ft. by 5 ft. deep, and is composed of 140 clusters, each of five 2-in. nozzles, each nozzle having a capacity of 40 g.p.m. with 7 lb. pressure. The body of this pond contains about 2,340,000 gal., and at the present rate of circulation, is circulated once every 80 min. Based on the amount of water circulated, the make-up required by the spray pond is about 1 per cent. This partially softened water has left no deposit whatever in the circulating system.

For boiler feed purposes, the lime and alum treated water is put through a two-unit zeolite softener to remove the remaining hardness, and into a 20,000-gal. tank located in the yard, which acts as a make-up storage. This is done by two centrifugal pumps located in the softening plant, with a capacity of 1000 g.p.m. against 100 ft. head. These pumps also handle the water for power house cooling. The soft water storage tank also supplies soft water to yard locomotives and to the slag plant of the blast furnace.

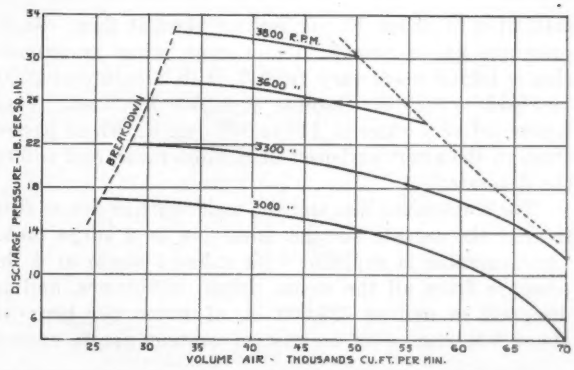


FIG. 2. CURVES SHOWING OPERATING RANGE OF TURBO-BLOWERS

Typical analyses of water are given in the table, while a flow diagram of the water is shown in Fig. 7.

TYPICAL ANALYSES OF WATER

		Raw water	After lime & alum	After acid	After zeolite
Total hardness	as $CaCO_3$	350	164	164	0
Calcium hardness	" "	225	100	100	0
Magnesium hardness	" "	125	64	64	0
Alkalinity - M.O.	" "	241	45	15	45
" - Pht.	" "	0	6	0	6
Causticity	" "	0	0	0	0
Free Carbon Dioxide	" CO_2	44	0	1	-
Chlorides	" Cl	85	86	86	86
Sulphates	" SO_4	113	140	164	140
Iron	" Fe	.4	0	0	0

Condensate from all the main units, after passing through the inter- and after-cooler of its respective condenser air ejectors, mixes with the required amount of make-up from the storage tank and then passes through a closed type heater, steam for which is bled from the sixth stage of the generator turbine, amounting to a

FIG. 1. TURBO-GENERATOR END OF POWER HOUSE

maximum of about 12 per cent of throttle flow. Shell pressures which prevail in this stage, when no extraction is taking place vary from 2.39 lb. absolute at 2500 kw. load to 9.25 lb. absolute at 12,500 kw. load. This heater delivers water at 140 to 160 deg. F., which passes through the after-condenser of the deaerator, and enters the deaerator.

The condensate line and the make-up line are so tied in that the outside storage tank acts as a surge tank. The deaerator is supplied with exhaust steam at 4 lb. pressure from all the steam driven auxiliaries, and is designed to deliver 325,000 lb. of water per hour at about 200 deg., with an oxygen content not to exceed 0.05 cc. per liter. A vacuum corresponding approximately to the temperature in the shell of the deaerator is maintained by a steam jet air ejector exhausting into the after-condenser, the condensate from which is returned to the generator condenser hot well. The deaerator has storage space for several thousand gallons of water. In a check made on this deaerator, the following results were obtained.

Average temp. water out of 1st stage heater	155.	deg. F.
Average temp. water out of after-condenser	165.2	deg. F.
Average temp. steam in deaerator tubes	299.	deg. F.
Average temp. in shell above tubes	207.5	deg. F.
Average temp. water out of deaerator	207.4	deg. F.
Average pressure of steam in tubes	9.23	in. Hg.
Average vacuum in deaerator shell	1.635	in. Hg.
Average oxygen content, cc. per liter	.019	
Lb. feed water through deaerator per hr.	238,000.	

Dual drives were put on the generator condenser circulating pump and on one of the furnace circulating pumps so as to give flexibility in the matter of heat balance. A flow diagram of the plant is shown in Fig. 8.

Located directly beneath the deaerator are three four-stage 5-in. centrifugal boiler feed pumps, having a capacity of 650 g.p.m. each against a head of 875 ft. at 1850 r.p.m., driven by steam turbines, with constant differential pressure regulators. Here also is an 18 by 12 by 24-in. duplex outside end packed plunger pump, which can be used in emergency either for boiler feed or for general service.

A 12 by 10-in. air compressor, driven by a synchronous motor, supplies air for general use in the power house, boiler house, and furnace, and for the regulators on the blast furnace gas burners on the boilers and hot blast stoves.

FIG. 3. BLOWER END OF POWER HOUSE WITH DEAERATOR IN THE FOREGROUND

Boiler House Is a Separate Building

Located near-by and parallel to the power house is the boiler house, a building 76 ft. 6 in. by 188 ft. 2 in. There are installed six boilers, each having 8900 sq. ft. of heating surface, with integral economizers of 4600 sq. ft. and superheaters of 760 sq. ft. surface each. Five are equipped to burn either blast furnace gas or powdered coal, and one to burn either coke-braize or coal. The boilers are designed to operate at 300 lb. pressure and 150 deg. superheat, while the economizers are built for 350 lb. pressure. Water is delivered into the economizers at about 205 deg., from which it enters the boilers at 325 to 375 deg.

Boiler settings were designed for 300 per cent rating on powdered coal, having a furnace volume of about 6500 cu. ft. Four burners fire coal vertically downward, the height of the chamber being about 30 ft. from burners to water screens. These screens have about 235 sq. ft. of surface each, and are placed sufficiently lower than the gas combustion oven so as not to interfere with combustion of gas.

Primary air for combustion of coal is drawn through ports in the outside of the settings and passes through

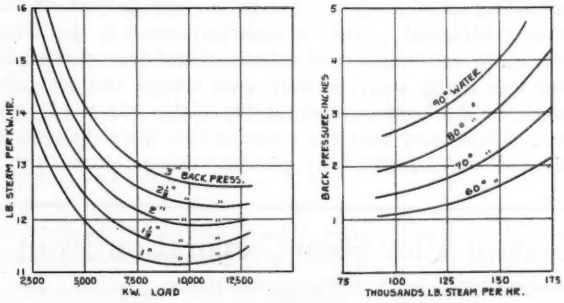


FIG. 4. OPERATING CHARACTERISTICS OF TURBO-GENERATOR
FIG. 5. OPERATING CHARACTERISTICS OF CONDENSER

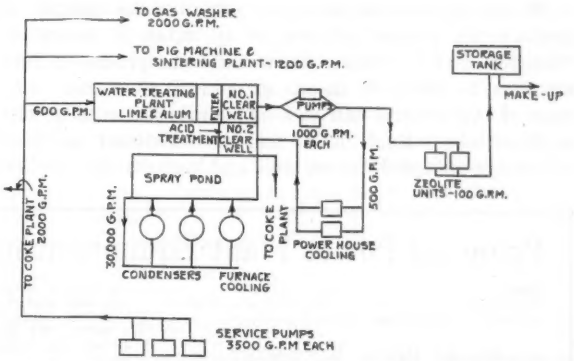


FIG. 7. FLOW DIAGRAM OF WATER SYSTEM AND TREATING PLANT

the hollow side wall blocks, where it is preheated to about 300 deg., then passes through the pulverizers and burners with the coal. Part of this primary air is introduced at the coal feeder of each pulverizer, where it absorbs a large part of the moisture in the coal. Samples taken in front of and after this connection show that only 2.5 per cent moisture remained in the coal fired, as against 6 per cent in the coal fed to the pulverizer. This evaporation of moisture enables the pulverizers to be worked at high rating. Secondary air is drawn into the boiler furnace from the room through ports on the front of the boiler. The boilers are completely encased with steel plates supported by steel buckstays.

Furnaces Equipped for Pulverized Coal and Gas

Coal is supplied to the five boilers by eight impact type unit pulverizers, six driven by motors and two by steam turbines. The pulverizers each have a capacity of 4500 lb. of coal per hour, with coal of less than 5 per cent moisture, and are so connected to the boilers that great flexibility of operation is obtained. The quantity of coal fed to each pulverizer is governed by a rotary feeder driven by a small motor, to which power is supplied from one of the generators in the motor generator set of the combustion control equipment. In an emergency, these feeders can be run by a belt from the main shaft of the pulverizer.

Each of these five boilers is also served by two blast furnace gas burners, capable of running the boiler at 225 per cent rating, located at the rear of the boiler, firing horizontally forward through an oven under the lower drums of the boiler into the main combustion space of the boiler. Each burner has automatic control to equalize the gas and air pressure in the burner. Preheated air is supplied to these burners by two 60,000 cu. ft. per min. fans, one driven by motor, the other by a steam turbine.

One boiler is equipped with a chain grate stoker having a grate area of 237 sq. ft., driven by a vertical steam engine or a motor. Coke braize is burned on this stoker with excellent results. An average of 14 per cent CO_2 can be maintained, varying somewhat with the rating, which reaches 300 per cent. Air is supplied by a 27,000-cu. ft. per min. fan, turbine driven.

Coal combustion is governed by automatic electrical control, actuated by steam pressure and flow. A master steam regulator operates from the steam pressure in the main, controlling a motor operated rheostat which varies the fields of the damper, secondary air, and fuel compensator generators. These three generators, together with the generator supplying power to the pulverizer feeder motors and a turbine and a motor arranged for dual drive, comprise a six-unit motor generator set which activates the control. The dampers and secondary air ports are all motor operated. Dampers are controlled by a regulator connected to the combustion chamber, which causes the stack damper to maintain within 0.03 in. the predetermined pressure desired in the combustion chamber. This pressure may be changed by a manual rheostat. Secondary air ports are governed by regulators operating from a differential pressure, connected to the combustion chamber and to the last pass of the boiler. The master control operates

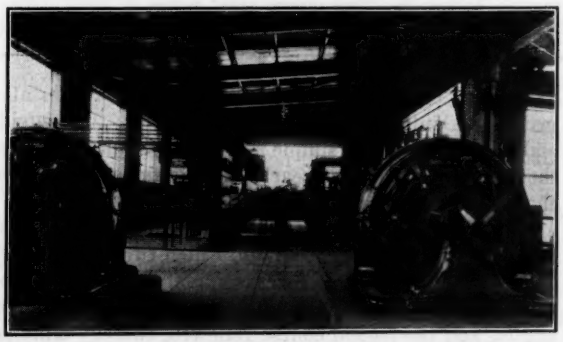


FIG. 6. VIEW OF SWITCH-HOUSE FLOOR

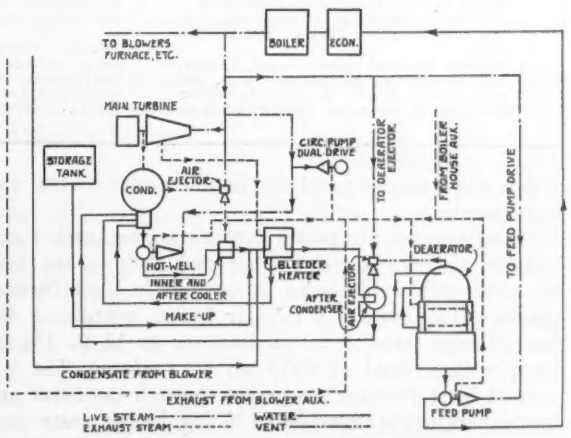


FIG. 8. FLOW DIAGRAM OF POWER PLANT

to fix the amount of secondary air and the amount of fuel in the proper relation at all rates of operation. Changes in this relation due to different grades of fuel, etc., can be offset by means of manual rheostats. Any item of this control can also be operated manually with push-buttons. Each boiler has an individual panel on which are mounted the controls and instruments for that boiler, and a master panel carries the master control and instruments.

Blast furnace gas passes through a dust catcher and whirler, through a wet washer and then to the heat inter-changer, which is an innovation in blast furnace plants. It consists of a tubular heater, containing 434 No. 10 gage tubes, 4 in. in diameter by 12 ft. 1⅝ in. long, with a total of 5450 sq. ft. surface. The wet washed blast furnace gas passes through the tubes and its temperature is raised 30 to 35 deg. by the waste stack gases from the hot blast stoves passing over the outside of the tubes. This rise in temperature with its corresponding gain in sensible heat is only a part of the benefit obtained. What is more important is the elimination or vaporization of entrained moisture carried by the gas, doing away entirely with sludge and scale deposit in the burners and on the boiler tubes. It was found necessary that the tubes of this inter-changer be flushed periodically. At present, this is done once a day. For this purpose, pipe manifolds were installed inside the inter-changer, with valves on the outside, making the operation simple and rapid. Since installing the flushing equipment early in November, the inter-changer has not been out of service.

All the boilers are served by one radial brick stack, 365 ft. high by 19 ft. at the top, which furnishes natural draft for all boilers. Before this step was decided upon, the problem was thoroughly investigated from all angles, and the logical course followed, thereby eliminating all operation and maintenance of fans for the purpose of operating at boiler ratings expected.

Principal Power Plant Equipment in Central Alloy Steel Corporation Plant

Location .....
Massillon Works of the Central Alloy Steel Corporation, Massillon, Ohio.

Boiler House Equipment

6 Babcock & Wilcox Co. Stirling boilers, 890 hp. with integral economizers; 300 lb. steam pressure. Five, blast furnace gas or powdered coal; one, coke braize or coal.
6 Babcock & Wilcox Co. superheaters, 150 deg. superheat.
5 Erie City Iron Works water screens, 235 sq. ft. each.
10 American Heat Economy Bureau Steinbart gas burners, 2 on each boiler.
20 Erie City Iron Works pulverized coal burners, 4 on each boiler.
8 Erie City Unit Pulverizers No. 4, Seymour Impact type, driven by
6 General Electric 75-hp., 900-r.p.m., 2300-v. motors, directed connected, and
2 Westinghouse 75-hp., 3710-r.p.m. geared turbines.
1 Riley Stoker Co. Harrington chain grate stoker, 237 sq. ft. area, driven by
1 4x4 Troy engine, with enclosed gear drive.
1 Buffalo Forge Co. fan for stoker, 27,000 cu. ft. per min. at 4.5 in. pressure, driven by
1 Westinghouse 30-hp., 3660-r.p.m. geared turbine.
2 Buffalo Forge Co. fans for air to gas burners. 60,000 cu. ft. per min. each at 7-in. pressure, driven by
1 General Electric 100-hp., 1800-r.p.m., 2300-v. motor and
1 Westinghouse 125-hp., 3380-r.p.m. geared turbine.
Feed water regulators (Copes) .....
.....Northern Equipment Co.
Soot blowers..Diamond Power Specialty Co.
Boiler arches....Liptak Firebrick Arch Co.
Boiler side walls.....
Waite & Davey air-cooled side wall blocks, Dobie & Co.
Ash hoppers and gates..Beaumont Mfg. Co.
Coal handling and crushing..Link-Belt Co.
Combustion control.....
.....Benjamin Engineering Co.
Stack .....
..Rust Engineering Co., 365 ft. x 19 ft.

Prime Movers, Generators and Auxiliaries

1 General Electric 10,000-kw. Curtis turbine, 9-stage, 1800-r.p.m., bleeder type, driving a 4-pole, 11,000-v., 12,500-kv.a. 80 per cent power factor, 3-phase, 60-cycle generator. Turbine designed for steam at 275 lb., 150 deg. superheat.
1 General Electric direct-connected exciter, type MPC-6, 75 kw., 250 v., 300 amp.
2 General Electric turbo-blowers, 3-stage, 3370 to 4150 r.p.m., 50,000 cu. ft. per min. at 18.4 to 32.7 lb. pressure, driven by 3950 to 5300-hp., 8-stage condensing Curtis turbines, designed for 275 lb., 150 deg. superheat.
1 General Electric generator air cooler, 2 units, 227 sq. ft. each.
1 Andale oil cooler, Andale Engineering Co.
2 Schutte & Koerting oil coolers for blowers.
3 General Electric synchronous converters, 6 pole, 550 kw., 1200 r.p.m., 250 v., 2200 amp., 6-phase, 60-cycle.
4 General Electric switchboards: 1 main board, 11,000 v.; 1 2300-v. distribution board; 1 250-v. d.c. board; 1 250-v. field control board.
Distribution transformers.....
.....General Electric Co.

Condensers and Auxiliaries

1 Worthington Pump & Machinery Corp. 14,400-sq. ft., 2-pass surface condenser for turbo-generator, equipped with duplicate 2-stage, 20-cu. ft. steam jet air ejectors, all mounted over one common surface inter- and after-cooler combined in one shell, equipped with valves so that either or both may be operated.
2 Worthington 6400-sq. ft., 2-pass surface condensers for turbo-blowers, each equipped with duplicate 2-stage, 11-cu. ft. steam jet air ejectors, mounted same as turbo-generator.

Pumps and Drives

1 Worthington 24-in. type OS centrifugal circulating pump, 16,100 g.p.m., against 45 ft. head, driven in dual drive by
1 General Electric type I-M-17-A 250-hp., 2300-v., 3-phase, 60-cycle, 600-r.p.m. motor, and
1 Westinghouse 250-hp., 4040-r.p.m. geared turbine.
2 Worthington 4-in. 2-stage hot well pumps, 315 g.p.m. against 85 ft. head driven by
2 Westinghouse 20-hp., 1750-r.p.m. turbines, direct connected.
2 Worthington 16-in. type OS circulating pumps, 7000 g.p.m. against 50 ft. head, driven by
2 Westinghouse 125-hp., 3370-r.p.m. geared turbines.
4 Worthington 3-in., 2-stage hot well pumps, 140 g.p.m. against 85 ft. head, driven by
4 Westinghouse 12½-hp., 1200-r.p.m. turbines, direct connected.
3 Worthington 10-in. 2-stage close coupled centrifugal service pumps, 3500 g.p.m. against 210 ft. head, driven by
3 General Electric 250-hp., 1200-r.p.m., 2300-v. squirrel cage motors, direct connected through flexible couplings.
2 Worthington 6-in. centrifugal pumps, 1000 g.p.m. against 100 ft. head, driven by
2 General Electric 40-hp., 1800-r.p.m., 220-v. motors, direct connected.
2 Worthington 10-in. centrifugal furnace circulating pumps, 3000 g.p.m. against 100 ft. head, driven by
2 Westinghouse 100-hp., 1750-r.p.m. turbines and
1 General Electric 100-hp., 1800-r.p.m., 2300-v. motor in dual drive.
3 Worthington 5-in. Jeanesville 4-stage centrifugal boiler feed pumps, 650 g.p.m. against 875 ft. head, driven by
3 Westinghouse 225-hp., 1850-r.p.m. turbines, direct connected.
1 Worthington 18-in. by 11-in. by 24-in. horizontal duplex plunger pump. Water end suitable for 500 lb. pressure, 500 g.p.m.
1 Nash Engineering Co. Jennings Hytor condensation pump, driven by
1 General Electric 3-hp., 1750-r.p.m. motor.

Water Treating and Heating Equipment

1 Permutit Co. 60,000 gal. per hr. cold continuous treating plant.
1 Permutit Co. 2-unit zeolite softener.
1 Griscom-Russell condenser type bleeder heater, 178,600 lb. water per hr. from 92 deg. to 149 deg. with 10,300 lb. per hr. bled steam at 7.4 lb. absolute.
1 Griscom-Russell Contraflo deaerating heater, 326,000 lb. per hr. from 140 deg. to 195 deg. with 18,200 lb. per hr. auxiliary exhaust steam at 5 lb. gage pressure.

Miscellaneous

1 Ingersoll-Rand air compressor, 12 in. by 10 in., direct connected to Electric Machinery Mfg. Co. synchronous motor.
Spray Pond.....Spray Engineering Co.
Centrifugal oil purifier.....
.....DeLaval Separator Co.
Motor operated valves (Dean Control)
.....The Cutler-Hammer Mfg. Co.
Valves, steam and water.....
.....Chapman Valve Mfg. Co.
.....The Edward Valve & Mfg. Co.
..... Lunkenheimer Co.
(Hancock) Manning, Maxwell & Moore, Inc.
Valves, blowoff, (Everlasting).....
.....Scully Steel & Iron Co.
Valves, safety, (Consolidated).....
.....Manning, Maxwell & Moore, Inc.
Valves, nonreturn .....
...Golden-Anderson Valve Specialty Co.
Cranes.....Morgan Engineering Co.
Steam flow meters....General Electric Co.
Pyrometers.....Brown Instrument Co.
Draft gages.....Bailey Meter Co.
Recording thermometers...The Bristol Co.
Recording pressure gages..The Bristol Co.
Indicating thermometers .....
.....Taylor Instrument Cos.
Indicating pressure gages.....Foxboro Co.
Venturi meter.....Builders Iron Foundry
Piping..Pittsburgh Piping & Equipment Co.
Pipe covering.....Keasbey-Mattison Co.
Atmospheric relief valves.....
.....Schutte & Koerting Co.

Usually the load is carried on the coke braize boiler and four gas fired boilers. At times, depending upon gas and load conditions one boiler operates on powdered coal. Coal is also used over the cast periods of the furnace. Average performance for a recent month is as follows:

Total boiler hours	3717
Average number of boilers used	4.99
Average boiler rating	161.7%
Average feed temperature	204.

This average rating is low, as it includes all Sundays and other periods of light load. Peaks of 326 per cent rating on coal and 243 per cent rating on gas are reached. Total monthly evaporation has reached over 160,000,000 lb., while a typical week-day evaporation is about 6,000,000 lb. in 24 hr. Investigation into the matter of blow-down led to the adoption of 300 grains per gallon as the desirable limit of concentration. Accordingly, boilers are blown once every six hours, the total blow-down averaging about 3.5 per cent of the total feed.

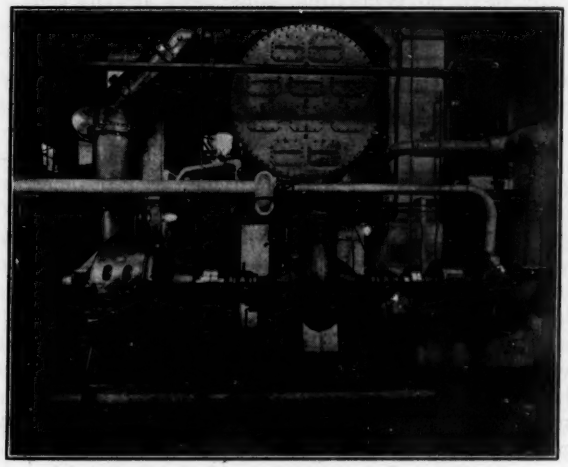


FIG. 9. CONDENSER AND PUMPS FOR TURBO-GENERATOR

Coal is dumped into a track hopper, passes through the coal crusher, over a conveyor with a magnetic pulley separator, and into a concrete pit, whence it is picked up by a 5-t. crane with a 2-yd. bucket and carried into the coal bunkers. Coke braize is dumped through a track hopper directly into a second concrete pit and then handled by the crane. A third pit receives ashes from a small dump car running under the ash hoppers of the boilers, whence the crane loads them into a railroad car. The coal bunker will hold a total of 1000 t. of coal, or about 650 t. of coal and 250 t. of coke braize.

Main steam valves are motor operated, with control stations both in the power house and in the boiler house.

The entire plant is well supplied with instruments, each boiler having a steam flow meter, a three-point recording pyrometer, draft gages, etc., while all main points of steam consumption are also metered. These, with the recording temperature and pressure gages installed provide means for a very complete check on the operation.

High Boiler Efficiency Obtained in Operation

Every effort was put forth to make the plant highly efficient and thoroughly reliable, and the results to date have been very gratifying. Since the blast furnace was blown in on October 28, 1926, the generator has operated continuously with an outage of only 9 hr., all of which was planned. There have been no unexpected interruptions. Averages to date show this unit operating as follows:

Steam pressure in chest	273	lb.
Steam temperature	560	deg.
Vacuum (corrected)	28.4	in. Hg.
Water rate, generator and auxiliaries	13.25	lb. kw-hr.

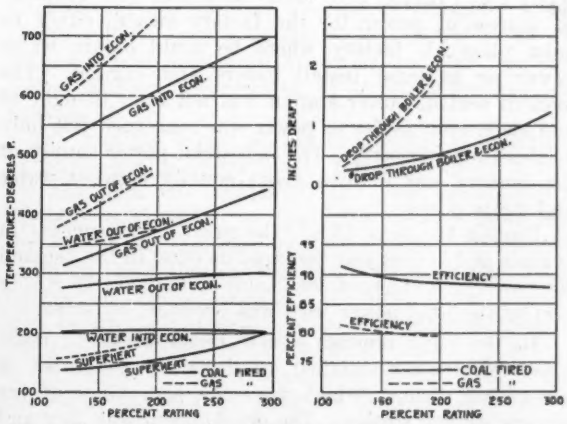


FIG. 10. CURVES DRAWN FROM TEST DATA FOR BLAST FURNACE GAS AND POWDERED COAL

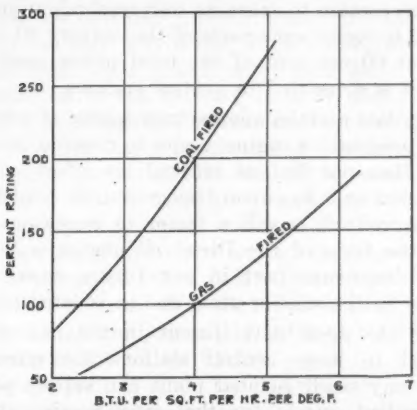


FIG. 11. HEAT TRANSMISSION IN INTEGRAL ECONOMIZER

Ohio slack coal is being used in the pulverizers, with good results. Following is an average indication of their performance:

	Sample No. 1	Sample No. 2	Sample No. 3
On 40 mesh screen	1.75	3.00	3.25
On 60 mesh screen	4.50	7.75	5.50
On 80 mesh screen	12.50	17.50	11.50
On 100 mesh screen	7.75	8.00	8.25
On 120 mesh screen	2.75	4.00	3.50
On 140 mesh screen	9.75	10.25	14.25
On 160 mesh screen	7.25	5.75	6.25
On 180 mesh screen	.75	1.25	1.75
On 200 mesh screen	12.25	11.25	10.25
Through 200 mesh screen	40.75	31.25	35.50

A series of boiler tests was run on one of these boilers and the curves in Fig. 10 give important items for all the tests.

Based on data obtained from these tests, heat transmission in the integral economizer is given for various ratings in Fig. 11. Gas and water temperatures at these ratings are given in the curves of Fig. 10. Tubes in this economizer are regular steel boiler tubes, 3¼ in. in diameter, No. 6 gage. With properly deaerated water these tubes show no corrosion, and complete satisfaction is obtained.

The plant was designed by Freyn Engineering Co. under the direction of Central Alloy Steel Corporation engineers.

Choosing Power for Factories

COMPARISON OF POWER COSTS IN SMALL AND MEDIUM SIZE FACTORY. BY WM. W. GAYLORD

FIFTY YEARS ago there were but two available sources of power for the factory owner; either he must place his factory where he could obtain water power or he must install boilers and engines. The modern central power station was not even thought of and electricity, as far as power was concerned was only a laboratory curiosity. The industrial power supply of the country was divided about equally between water and steam power.

During the next 15 yr. the great improvements in engines and boilers and the large increase in the demand for power had changed conditions so that nearly 80 per cent of the total power used was produced by steam.

In the early nineties a new factor began to make itself felt; power supplied by electricity generated in generating stations which were the beginnings of the modern central station. The development was slow and somewhat uncertain at first, but the convenience, adaptability, and efficiency of the new source of factory power was certain to cause its universal adoption in the end until today in some parts of the country 80 per cent and about 60 per cent of the total power used in the industries is generated in central stations.

In the late nineties another new source of power, the internal combustion engine, began to demand notice and while it has not had as marked an effect on power development as it has upon transportation (which it has revolutionized) it is still a factor to be reckoned with and in the form of the Diesel oil engine is bound to play an important part in our future power supply especially in the smaller units and in isolated places.

Since the great development in the use of power generated in large central stations the question of whether any small isolated plant can supply power at an equivalent cost is one that must receive attention. The representatives of the central station claim that power can be purchased cheaper than it can be generated by the small factory in most cases. They further claim that where the cost of generating is less than the purchase price the same amount of money invested in other parts of the factory will show a greater return. The builders of generating equipment on the other hand claim that power can be generated at a considerably lower price than it can be purchased. A careful study of the situation shows no fixed rule can be given as the relative cost of purchased and generated power varies with every individual case, but that some general rules can be established that will assist in analyzing any case in question.

First: The cost of generated power is found to be composed of three main items; fuel cost, labor cost, and investment cost. With a given installation, the investment cost is fixed while the fuel and labor costs vary more with the hours and method of operation.

Should the factory require low pressure steam for heating or process work only that part of the fuel and boiler room labor costs which would not be required were there no generating units need be charged to power. In this case the investment cost often becomes the governing factor, and where this can be kept reasonably low it will frequently be found that generated power costs less than purchased power even in units as small as 75 kw.

Second: The choice of generating equipment must be suitable for the operating conditions. For instance, in plants having an average power load of less than 300 kw. where there is an all-year demand for low pressure steam sufficiently large to take all the exhaust steam it would be advisable to install a turbine because its high water rate will be of small importance when all exhaust is used and its lower first cost will reduce the investment costs charged to power. If, on the other hand, only a part of the exhaust steam can be used, a uniflow engine in spite of its first cost will probably prove more economical as the fuel charge will be so much smaller. In cases where the power demand is larger than 300 kw. and where all the exhaust steam from a unit of this size can be used only in extreme weather, it is often economical to install a bleeder type turbine or else two units, one to be run non-condensing, and the other condensing and shift the load between them in such a way that the non-condensing unit carries only load enough to supply the required exhaust steam.

Where little or no steam is used for process or heating, an oil engine of the Diesel type may prove the most economical, since while both the first cost and upkeep will be greater, the fuel cost will be exceedingly low. With engines of the Diesel type it is possible to install exhaust heaters that will supply considerable hot water or even low pressure steam, although in most cases an auxiliary boiler plant will be required to raise steam before the engines are started. While oil engines are relatively new in this field they have now been developed to a point of reliability and simplicity where they must be considered in any study of factory power.

If power is to be purchased there are two points which should be considered to get the most economical rates. Most of the central station rates now in use have some form of demand charge which means that the average rate for all current purchased will depend to a large extent on the ratio of maximum kw. demand to the average kw. load. This means that the plant in

which the average load most nearly approaches the maximum demand will pay the lowest rates for current, while the plant where no effort is made to keep the maximum demand down will pay a higher rate. Many rates also have a power factor clause which involves an extra charge if the power factor is below 80 per cent. This means that to obtain minimum rates the motor sizes should be so chosen that the average load on each motor is as near as possible to its rated load.

Two Plants Analyzed

To illustrate how the relative costs may work out, the writer has recently investigated the relative cost of generated and purchased power in two factories in entirely different lines. In the first there was a considerable use of low pressure steam and hot water in process work as well as the heating system which required low pressure steam seven months in the year. There were two boilers of about 150 hp. and designed for 150 lb. working pressure installed. The average electric load was about 80 kw. and the maximum 116 kw. The total electricity used per year was 190,000 kw-hr. and the cost when purchased $5500. The heating system installed had the equivalent of 11,600 sq. ft. of cast-iron radiation and the average steam process load was 1800 lb. per hr. The power load was somewhat larger in the winter than in the summer and it was found, after a careful analysis of both the steam and power loads, that if a 125-kw. generator driven by a uniflow engine was installed, all the power required could be generated and little exhaust steam wasted, although in the heating season considerable live steam would have to be used. The installation cost of this generator with all the piping, switchboard wiring and building changes required was found to be $14,500. The yearly cost of power was estimated to be $2940. This was figured to include all added fuel, labor, supplies and repairs to run the engine and generator as well as 9 per cent on the investment for depreciation, taxes and insurance. This shows an annual saving of $2560, or an earning of 17.6 per cent on the investment, proving that in this case generating equipment is a good investment.

In the second case the average load was about the same; i. e., 75 kw. but the maximum demand was only 95 kw. The total electricity used per year was 210,000 kw-hr., due to longer hours. Here also boilers were already installed and there was room to install a generator. The process steam load, however, was only 300 to 400 lb. per hr. The heating system load was the equivalent of 6500 sq. ft. of cast-iron radiation, but due to nature of the work, much less heat was used in the buildings during the daytime when power was required. Here the average price paid for purchased power was only about 2.8c per kw-hr., due to the high load factor. An analysis showed no type of steam-driven generating equipment could be installed which would supply the necessary power without wasting a large amount of exhaust steam for a considerable part of the year. An estimate of the yearly cost of generating power showed that if 6 per cent interest on the investment for generating equipment was figured in addition to the 9 per cent for depreciation, taxes and insurance and these added to the costs of fuel, labor, supplies and repairs as before, the total would be equal to, if not greater than the cost of purchased power.

An investigation of the possibility of using a Diesel oil engine in this case showed an installation cost of about $20,000, a cost of current at the switchboard of 2.84c per kw-hr. In this case generating equipment is not a good investment.

The foregoing examples show how necessary it is to analyze each case on its own merits.

Electrical Output Estimated to Reach 80 Billion Kw-hr. During Year

An estimate based on the output so far this year and on comparable figures for 1926 indicates that the total output for 1927 of electricity by public utility plants will be approximately 80,000,000,000 kw-hr., as compared with 73,800,000,000 kw-hr. for 1926, the Geological Survey, Department of the Interior has just announced.

The monthly report of the production of electricity by public-utility power plants for May showed a total for the first five months of the year amounting to 32,400,000,000 kw-hr., or about 9½ per cent more than the output for the same period in 1926. An estimate based on the output so far this year and on comparable figures for 1926 indicates that the total output for 1927 will be in the neighborhood of 80,000,000,000 kw-hr. The total for 1926 was 73,800,000,000 kw-hr.

The effect of the increasing hours of daylight and the rising temperature from the first to the middle of the year on the demand for electricity for light and heat is shown in the decrease in the average daily production of electricity that occurs during this period each year. This year the decrease in the average daily output from January to May was about 3 per cent; in 1926 the decrease was about 5 per cent; in 1925, 6 per cent. The lessening of the decrease in 1927 may be due, in part, to the increasing load for electrical refrigeration.

The average daily production of electricity by the use of water power in 1927 has set a record for each month from March to May. As the amount of electricity produced by water power is directly dependent on the amount of water flowing in the streams used for the development of power, it is expected that the output will begin to decrease after the month of May, as March, April and May are generally months of maximum flow for streams in the United States.

Notwithstanding the record-breaking output of petroleum this year, the consumption of fuel oil by public utility power plants has decreased each month and the consumption in May was less than in any other month since the Geological Survey began to publish monthly power reports in 1919.

Since an insufficient number of blowoff connections in wide boilers may also cause localized scale formation, practice in this connection was investigated by the N. E. L. A. Two cases of localized scale formation in the center tubes of boilers having only two blowoff connections were reported. Although several companies report no trouble with only two blowoff connections, a large number of new installations are equipped with more than two, in some cases as many as six connections being used.

Sawdust and Powdered Coal Burned Together

Modern Power Plant with an Efficient Cyclone System for Collecting Sawdust and Shavings Solves Wood Refuse Problem for the Hayes Wheel Co. By D. J. Lyons*

WHEN THE PROBLEM of burning wood waste became acute a careful analysis indicated that the proper course to pursue was to build the power plant shown in cross section in Fig. 1. This plant consists of three 425-hp. Stirling boilers and generating equipment capable of carrying the load of this division, the parent plant of the Hayes Wheel Co.

Only in rare cases can an isolated power plant cope with that of public utilities. A survey made by H. K. Ferguson Co. and our own engineering department showed, however, that the amount of refuse produced each day was capable of generating steam for the power required in the plant and also that necessary for factory heating and 138 dry kilns for approximately 19 hr. each day. It would be necessary to burn coal the remaining 5 hr. a day and during certain periods it would also be necessary to burn both coal and refuse at the same time. These were problems that required no small amount of research but which were finally solved successfully.

*General Works Mgr., Hayes Wheel Co., Jackson, Mich.

Ninety per cent of all wood refuse is obtained from the spoke turning plant consisting of 38 spoke lathes, four stickers and 12 spoke polishers. In order to eliminate the fire hazard, dust from the polishers had to be separated from the solid refuse or shavings. This was accomplished by the installation of a battery of Sly dust arresters placed outside of the spoke plant. The dust is collected in containers to be used in the automatic screw and other departments in which oil or cutting compounds are needed.

After separation from the dust the solid refuse and shavings are carried through a series of blow pipes to an Arlington-Curtis cyclone system located above the boiler room as shown in Figs. 1 and 2. From these cyclones the fuel is dropped by gravity into a shaving stoker which in turn feeds it through the top of the dutch oven where about 90 per cent of it burns in suspension.

Small steam jets placed in the feed pipe between the stokers and furnace serve a double purpose, first to break up the shavings which have a tendency to cause a clogging effect at the end of the stoker where they are not being broken up and carried across the stoker in an even mass and, second, the action of jets tends to prevent back firing from the furnace.

Hog Seldom Required

For accumulations of coarse wood a hog, driven by a 60-hp. motor and equipped with a 50-hp. fan, is provided but because of the nature of the wood refuse

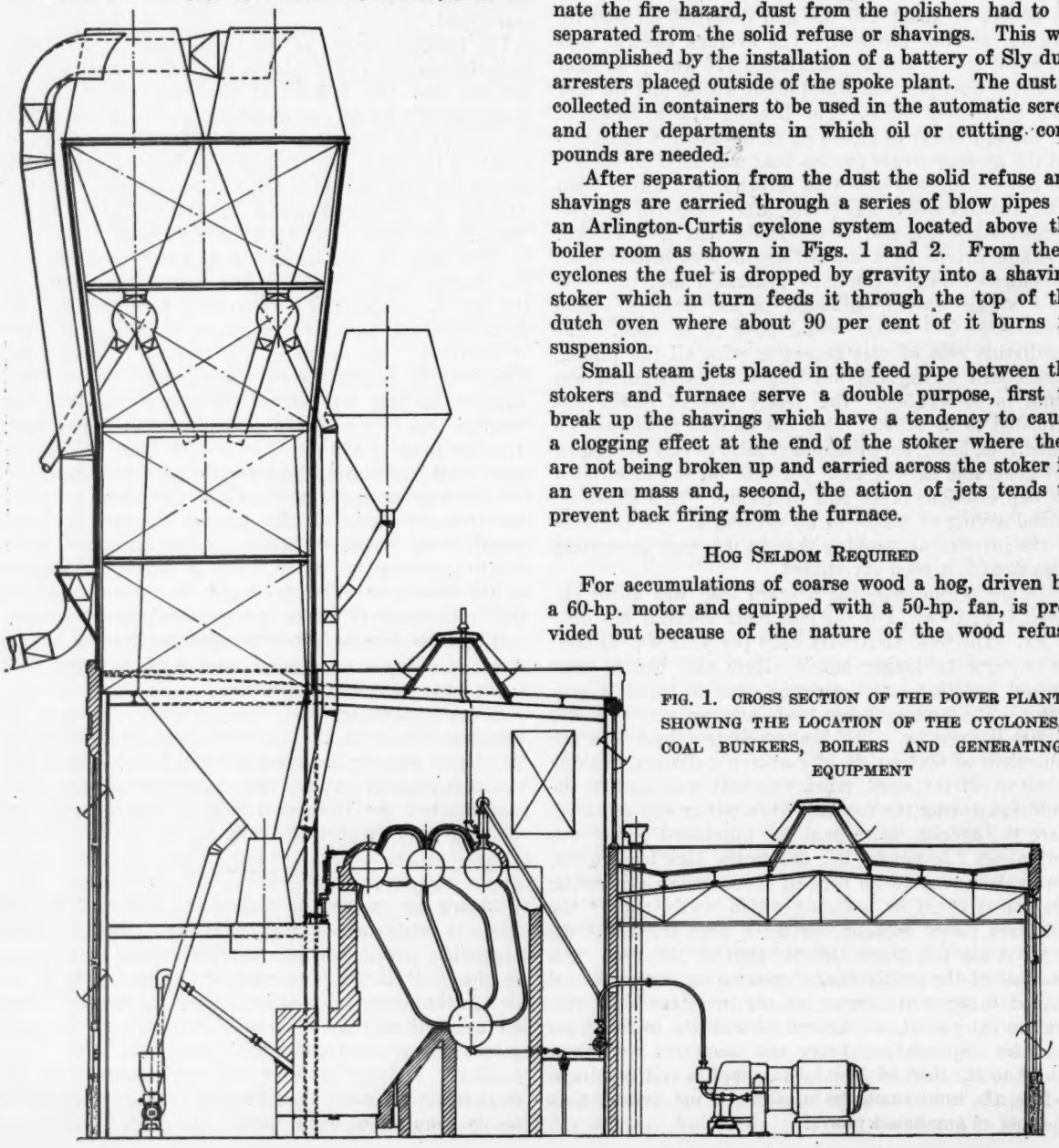


FIG. 1. CROSS SECTION OF THE POWER PLANT SHOWING THE LOCATION OF THE CYCLONES, COAL BUNKERS, BOILERS AND GENERATING EQUIPMENT

ordinarily obtainable it is seldom used. All the wood refuse is hickory and the B.t.u. per lb. as against the same weight of coal is approximately 33 per cent greater. Because of the fact that this fuel is dried down to a point of about 4 per cent moisture, it causes disintegration on both side and bridge walls, a problem of no small concern.

It became necessary to call in the research department of the University of Michigan, whose findings resulted in the fact that this type of fuel gives off approximately 14 per cent of free alkali whose contact with the fire brick sets up a chemical reaction causing disintegration. This makes it necessary to use a special brick, the one giving the most satisfactory service being Hi-Brand flint brick made of Missouri clay. Previous to this installation the walls and arches would not stand up more than five days, whereas since changing over,

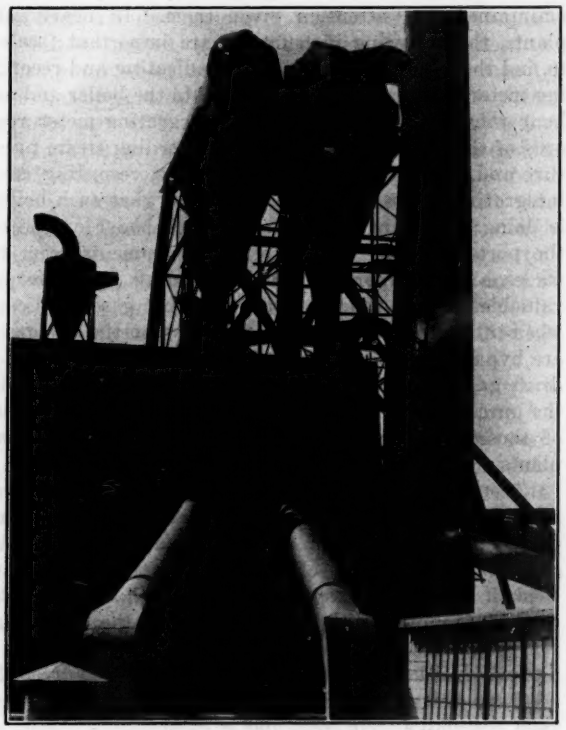


FIG. 2. SAWDUST AND SHAVINGS ARE COLLECTED IN LARGE CYCLONES LOCATED ABOVE THE POWER PLANT

the combination of this brick with the Detrick flat arch gives from 12 to 18 months service.

Coal Unloaded by a Unique System

Coal is unloaded from cars by a suction system, carried through a semi pulverizer and blown into storage bins located over the boilers. This unloading fan, shown in Fig. 4, is located in a small shed adjacent to the track. Coal being unloaded from the car passes through the fan and is crushed to a size ranging from ⅛ to ½ in. in diameter, after which it is elevated a height of 60 ft. to a cyclone and delivered by gravity to the storage bins above the boilers. This installation operated by a 50-hp. motor will unload an average 50-t. car of coal in 9 hr. The coal being used at the present time

FIG. 3. SAWDUST AND SHAVINGS ARE FED THROUGH THE TOP OF THE DUTCH OVEN BY STOKERS AND COAL IS FIRED THROUGH THE FRONT IN PULVERIZED FORM

is mine run, usually containing a great deal of slack and at times lumps varying from 6 to 8 in. in diameter.

From the coal storage the coal is fed to the boiler by Newcomb automatic firemen, giving the same result obtained as when burning wood refuse, namely, that of being burned in suspension. When entering the boiler approximately 60 per cent of the coal will pass through a 100 mesh screen.

This well planned installation and the successful elimination of difficulties have placed the plant on an efficient operating basis, which has a natural tendency to show low cost figures. Because of the vast amount of

FIG. 4. COAL IS UNLOADED AND ELEVATED TO THE BUNKERS BY A SUCTION UNLOADER

wood waste accumulated each day making necessary the purchase of only a small amount of coal, it has been possible to deliver power at approximately 8 mills per kw-hr. ($0.008). The sawdust stokers are run at a constant rate of speed and the load swings on the boilers taken by the automatic coal fireman. This automatic operation of both the wood and coal feeding equipment has reduced boiler room help to a minimum.

An audit made by a reputable concern after one year's operation shows that the power house equipment has been paid for in 13 months. In other words, the initial cost of the equipment, plus the interest and depreciation as balanced against power bills of the past for a like period brought about this condition in slightly over a year. The average boiler rating is about 225 per cent with a peak capacity of 275 per cent. When burning coal alone an evaporation of 7 lb. of water per pound of coal is obtained.

Operating the Industrial Plant

RECORDS NEEDED, OPERATION AND MAINTENANCE PLANNING, REGULAR INSPECTION, WASTE LOSSES. BY JOHN J. NOVOTNY*

CORRECT and effective methods in the important field of power plant operation may be considered in two aspects: First, the methods to secure best economic results with equipment in hand and, in sequence, what changes in or additions to present equipment will increase economy; second, methods which will promote safety, comfort and continuity of service.

Such knowledge can be attained only by studying the history and nature of power generating apparatus and its operation, and by devising correct methods and applying them correctly at the proper time. You cannot expect to get this information by wishing you had it, but must do extensive reading and studying in figuring out how to solve daily problems.

RECORDS ARE ESSENTIAL TO PLANT ECONOMY

Successful power plant operation depends greatly upon the records that are kept. The larger the plant the more important it is that the records be complete and absolutely correct. You may have the best possible crew of men; yet if you have neither records nor knowledge of the importance of such records you can not show the best possible results.

Study of the importance of power plant records shows that they are necessary for various reasons: first, in the determination of unit cost; second, in the determination of efficiency; third, in the indication of ways for reducing costs; fourth, in the indication of needed improvements and as a guide to operators. Log sheets must be made according to the conditions of the plant and revised as found necessary.

In order to put any plant on a sound footing you must have organization, co-operation and effective discipline. By discipline I mean the ability to take orders, the habit to be prompt, and a strong sense of duty. When these habits have been implanted one will be able to take responsibility and enjoy it.

In order to maintain the physical condition of the plant, careful, clear and definite plans must be made daily. The equipment must be systematically repaired or replaced, so that it can function properly and necessary tools and supplies or materials provided to carry on the work. For this program a system of records is necessary; otherwise the work is managed blindly.

The daily operation log sheet and maintenance records contain the changes made day by day and are not only the greatest aid to the engineer in keeping his plant tuned to the highest pitch, but are a guide to the operators, enabling them many times to avoid mistakes.

*Chief Operating Engineer, University of Wisconsin.

IMPORTANT INSTRUMENTS FOR KEEPING RECORDS

Possibilities of saving through the intelligent use of recording instruments are great if their operation is maintained and attention given them. In nearly all plants, the following instruments are important; scales to find the correct weight of fuel; indicating and recording meters to measure the water fed to the boiler and an hour rate record; recording and integrating meter records of the kilowatt-hours output; recording steam pressure and air pressure gages; indicating, recording, and integrating steam flow meters to show what each boiler is doing; recording pyrometer on each boiler or one of the portable type. The last two instruments seem to me especially important. The recording pyrometer is valuable to show the temperature of exit gases, indicate when tubes need blowing outside and when the flue gases are bypassing due to leaky baffles. A hand orsat and a draft gage are also necessary. One important point in the purchase of recording instruments is to buy the best of those that have been used with success in similar plants.

Accurate daily records should be kept of all material received and personal inspection made of every detail of the plant equipment, always remembering that the safety and continuity of service is no better than its weakest parts. It is well to repeat the old axiom "Take care of the little things promptly, and the big things will take care of themselves" and service after all, I believe, is what counts. Finally study your records, condense the results in monthly and yearly reports and then determine your costs and efficiency.

FUEL PROBLEMS BEAR INVESTIGATION

Many valuable articles have been written about coal and fuel, purchasing coal, either on open market or B.t.u. method. Almost every one is intensely interested in the cost of coal, yet few people are actually enough interested to direct properly the conservation of fuel or to make any effort toward stopping fuel waste.

Fuel waste must stop. It has been estimated that $500,000,000 are wasted annually, which should encourage every engineer or operator to save every pound of coal possible, or make one pound of coal do more than it formerly did. To illustrate, of the one ton of coal in the ground, say 2000 lb., the best recovery is 1700 lb., the average recovery is 1400 lb., and poor recovery brings only 1000 lb. of which 100 lb. is needed in mining and transportation.

To turn this coal into useful work at the point of application, the best large stations get the benefit of

608 lb.; some of the smaller central stations, 304 lb.; the best locomotives, 175 lb. and the average industrial plant, 75 to 80 lb. Just think of the losses and the possibilities for saving. These facts are the fundamental reasons for investigating and promoting super-power plant operation at or near the coal mines.

Coal will never return to pre-war prices and it behooves us as engineers to obtain the maximum production of steam with the minimum of waste. How can this be accomplished in your plant? There is no cure-all patent medicine for the solution of the conservation problem, but there are plenty of well-tried methods of stopping present wastes.

Plant Inspection Should Be Done Regularly

One sin in power plant operation is a lack of attention to details or a lack of proper and prompt inspection of all operating equipment. Power plant operation must have regular periods of inspection and, once such a habit is formed, you cannot get along without it. Make your observations regularly and frequently. Occasionally something turns up and you miss a point, but take care of it the next period. Any employer has a right to 8 hr. of his employe's undivided attention.

Oftentimes you hear the complaint that it is hard to get results out of some operator. This is usually due to a lack of just and clear information. It is not enough to ask one to perform a certain duty but you must tell him why it should be done and try to explain the importance or value of such performance. If an order is clearly understood, I believe you will have no difficulty in getting results.

I find that men get along and obtain results when they understand each other. Successful leadership today consists in perfect team work, an exchange between the engineer and his associates as to ideas, comments, suggestions, and the inviting of free and frank discussion on a subject. A leader should analyze a problem and make a decision which the entire crew will understand well enough to execute.

Operators should come on duty promptly and better than that, a few minutes ahead of time, in order to pass the time of day in a friendly manner and allow the retiring shift to give such information as is necessary. The engineer should make a brief inspection of the plant before taking his shift and look over the notes that may be placed on the log sheet. This applies to any kind of work. Then look over every detail in your charge such as the blowing down of the gage cocks. Take coal and water readings promptly. Look over your fires according to your load. Operate your boilers intelligently according to the grade of coal. Try to save every pound possible by careful cleaning of fires and by feeding coal properly.

Stop and think and say to yourself, "Am I getting all I can out of this coal? Is my feed water as hot as it should be? Is the flow to the heater the right amount and am I sure that the heater is not overflowing? Are the steam traps which take care of the condensation of the steam header working properly?" This matter is often neglected. "Are you making use of every heat unit after you have evaporated the steam, by using all the exhaust steam and are you using every pound of condensate possible?"

One of the most abused of all pieces of operating equipment is the boiler feed pump. Why? Because it is usually a long way off, not properly oiled, with packing leaking badly and often with every part badly worn. A pump is troublesome and when it fails it creates a most aggravating situation. How can this be avoided? By having at least two boiler feed pumps. Run them for regular periods. Make careful inspection of each regularly; see that your valves and pistons are right and have the best oil. Oil often but sparingly without waste. Examine the valves and valve seats occasionally. Have a pressure gage on the discharge line as a tell-tale, which will show the variation on each stroke and, above all, see that the check valves on the feed line to the boilers are in good working order. Poor check valves on the boiler feed line will cause pump trouble and at times give you much worry.

Are the boiler settings tight? If not, see that they are made so. How often are the tubes scraped or dusted with soot blowers and hand lance? Blowing tubes is always considered a disagreeable job. Why? Because the operator fails to realize the importance of it or does not keep his equipment in first-class condition. The steam hose leaks. You have dark places, shaky ladders, warped boards or sloping runways without hand rails. All these conditions are unnecessary and make this job a hard one.

Have you a water softener? How many of the crew know or care to know anything about the purpose of it, how to operate it, how to test the water, how and when to inspect it. Can you take care of it when it gets out of order? If you are using scale solvent, do you know what effect it is having? Is it fed properly and regularly?

Each engineer should and is entitled to feel proud when his boilers are clean inside and out, settings in order, attachments clear, no leaks, no baggy sheets or tubes, and the furnace and the stoker in such condition that he would be glad to invite any one in to see them operate at any time.

The power house is always considered a dirty hole and it will be so unless the operators themselves are clean and particular. Each one must make a special effort to keep it clean. There are many times when the best boiler room will be flooded and covered with dust and soot. About that time you get caught with a dirty engine room, but this is excusable if it is the exception and not the rule.

Other losses in power plant operation are due to radiation from uncovered boilers, bare pipes, or poorly fitted pipe covering, or losses due to leaky apparatus such as baffles, blowoff valves, safety valves, traps, stuffing boxes on steam water column valves. There are losses due to waste from overflow of water in heaters, tanks, showers, cooking or sterilization devices, waste of brick and cement due to improper handling of tools and use of worn tools, waste due to poor firing which is usually caused by carelessness or neglect.

There is waste of time and money in not keeping records of materials needed and not buying in proper amounts. In buying materials for stock one should know what material can be properly stored and whether it is likely to be ruined when exposed to weather or dampness. Much material is apt to be wasted in careless handling or by not being kept in order. It is really

surprising how much material can be easily stored if it is kept in order. One should always strive to make use of unused material instead of buying new.

Heating system equipment requires much attention and each section or building should be gone over during the summer, making necessary repairs, so that the system will be ready to operate successfully when the heating season begins. Real saving is possible by having proper temperature regulating equipment.

Motors, ventilating equipment, fans, and elevators are usually neglected and they too need thorough weekly inspection. Return pumps and traps, tunnel sump pumps, vacuum pumps, steam mains, expansion joints, reducing valves, valves and fittings, pipe supports, pipe covering and pressure gages should be inspected daily without fail.

Safety and efficiency are necessarily closely related. Even with efficiency, serious accidents occur to both the operator and the public and it is the chief engineer's duty to take special interest in warnings to the operators and to the public, especially when new construction work is going on.

See to it that there is proper lighting of runways, and step ladders and that you have appropriate danger signs, especially in the boiler room. Also provide goggles and first aid cabinets and gas masks for the refrigerating room. Hand railings should be installed, and sufficient fire escapes which are kept in repair.

If fire fighting apparatus is under your care, have a complete inventory made of that equipment so that you will know its condition and what is needed. Provide proper tools and fire extinguishers. Overhaul such apparatus as you have. Inspect the sprinkling system, the signal system and the fire pumps frequently.

Water mains and hydrants are often neglected so that frequently it is impossible to find the location of the main shut off valves in case of a break in the line due to frost or accident.

Sewers and plumbing equipment are a source of expense unless inspected frequently. Repairs should be made promptly or there will be a decided loss due to unnecessary leakage and high cost when repairs are finally made.

One concluding suggestion; keep a daily notebook in which you can record operating conditions or suggestions that come to you from time to time and you will find these notes valuable when making out your annual report.

Make the Plant Ready for the First Snow Storm

From Coal Handling Machinery Through to the Steam Main, Repairs and Replacements Should Put Everything Shipshape. By C. J. Wilder*

TO THE WRITER it has always seemed that winter approaches quickly after we celebrate July 4th. While the weather is hot and muggy, winter is in the offing ready to swoop down; hence, to be prepared, we must make a general inspection of the plant and remedy any and all defects while summer is still with us so that no tie-ups will take place during the cold months. Let's see what we are to inspect and repair in the steam generating end of the plant.

Starting at the beginning, the locomotive crane which hauls in coal and places it in the hopper needs attention; next the crushing, elevating and distributing conveyors, the storage bunker and the electric larry. This brings us to the stokers and after that comes ash handling machinery, the forced and induced draft fans, economizers, feeding appliances, heaters, safety valves and other auxiliary apparatus.

The Coal Storage Crane Comes First

We must make a thorough inspection of boilers, engines, gears, clutches, brakes and cables on the crane, as the cold months are extremely severe on this apparatus and the plant really starts all operations from this locomotive crane. The first thing, we find it has a few bad tubes and really it is more work to expand the tubes in the fire box on a small vertical boiler than it is to install new tubes in large boilers. But after two days of real work, a hydrostatic test shows the crane boiler in first class condition only that the same test reveals a leaky throttle. This throttle valve has to be repaired time after time until the wearing parts are entirely useless, so it is absolutely legitimate that we order a new valve. But at this time crane engineer says, "If you put on a perfectly tight valve, when she's stopped for 15 min. everything will be full of water. I'd rather have her leak a little—I like to have 'em leak a little." By the way, he is a new man. In fact, he is a good crane operator but we are not going to have the throttle leak so badly that the reversing gear has to be on the center every minute the crane is not in operation just to keep the pipes dry. Of course we insist that the operator center the gear when he leaves the cab.

When we install the new throttle, we provide for the condensation by installing a drip pipe attached to the bottom connection of a tee just ahead of the throttle, which cures the trouble and satisfies our crane operator, at least partially.

Next we find that the boom cable is in good condition but that the bucket cables are more or less worn. The job of retubing was work, but oh, how the repair men hate to stretch a bucket cable. At this point the engineer informs us that the clam shell seems to stick at times and the chain tries to jump off the sprocket. We find a tooth broken and the next one so badly bruised that we have to renew the sprocket.

But now coal in the bunkers is getting short so we have to desist for a couple of days until the storage can be replenished. As we go back to the crane our engineer informs us that sometimes the engine seems to stick and he has to kick the throttle almost wide open to start. I ask which cylinder seems to bother and he does not seem to know how to answer the question so we place the right engine on the center and open the throttle. No bother at all, the engine works perfectly; but when we do likewise to the left engine there is very poor response. On examination the cylinder rings on the right hand are found to be broken so that steam is blowing by. When this engine is on the center and the left-hand engine is operating, everything is good; but

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when conditions are reversed and the right-hand side has to start the load, the throttle has to be opened the limit.

After the cables are stretched and new rings installed, the crane works 50 per cent better but we have to put liners in the wristpin and crankpin in order to drive the keys properly. We have spent a couple of weeks at dirty, laborious work and can gamble that the crane is in better condition than it has been for two years. We cannot, however, positively guarantee that the cable will not snap in zero weather, and there is no way to guard against this.

We find the crusher gears are wearing more or less sharp and that one of the bearings will have to be renewed. As we carry these parts in stock, it is really no hardship to repair the crusher. By keeping the stoker bunker well filled with crushed coal, a repair job can run into two days before we need feel alarmed.

In the elevator and distributor conveyors, we find that worn links and sprockets bother the most with, of course, several pin renewals. The bearings are more or less exposed to the dust but are made heavy enough to stand a lot of abuse. The electric larry needs hardly any repairs, just a small gear on the driving mechanism.

Now the Furnace

A supply of stoker parts is always kept on hand and the machines kept in repair as well as possible so that no big repairs will ever bother, but occasionally a slip takes place and then hand work follows for a whole day. At this time we are careful to put the fire boxes in shape for the winter. In the old plant where the boilers are hand-fired, we line the fire boxes with headers for six or eight courses, which protects the fire box from the effects of breaking clinker from the side walls and makes a lasting job. Then we use a high grade fire cement. Ordinary fire clay is just as good to take up the unevenness of the brick work but does not hold its shape next the fire and the edges of the brick become exposed, causing spalling. After a wall is laid, a good washing with plastic cement will act as a protector and save its cost many times over.

In high furnaces the tendency is to cave away and fall in, if the inner wall is not properly anchored. It is no uncommon thing today to have fire walls 15 ft. or more in height and these walls must be properly secured at several points in order to stand a winter's run. Anchor irons are being used more or less and walls are built in arch formation when possible. The spray gun is also beginning to play an important part in furnace maintenance. A light coating of plastic cement may be applied at specified intervals saving spalling of the brick and prolonging the life of the wall two or three times.

No suggestions can be given that will cover all conditions, as every type of furnace has its own design and needs special treatment. That is where experience plays an important part in determining just what treatment each kind and type of furnace will require. While we are taking every possible precaution to lay up a wall which will stand its particular inferno, we must not neglect the outer wall.

Some twenty-five years or so ago, the average engineer or fireman was quite a bit hazy about the hand Orsat. When it was mentioned in a gathering of the clan there was considerable agitation on the outskirts as to whether it was a new kind of clam bake or a damper regulator, but today even the pump operator knows that too much air means poor CO_2. To keep out this air the outer wall must be air proof. The headers in water-tube boilers must be calked with asbestos to prevent air seepage and, where hollow stay bolts are used, the plugs must be kept in place. Where water legs are a part of the construction, the bottom and sides must be kept packed; in fact, if the furnaces are to be operated on 20 per cent excess air, that air should come in only through the grates, not above or around them.

In the horizontal return tubular boiler, the combustion chamber arch is often found more or less of a care. Several years ago in making furnace tests we found that three out of five horizontal boilers dropped five to seven per cent CO_2 through the combustion chamber arch. Where the arch comes in contact with the rear head of the boiler, or more properly speaking, where arch does not come in contact with the rear head,

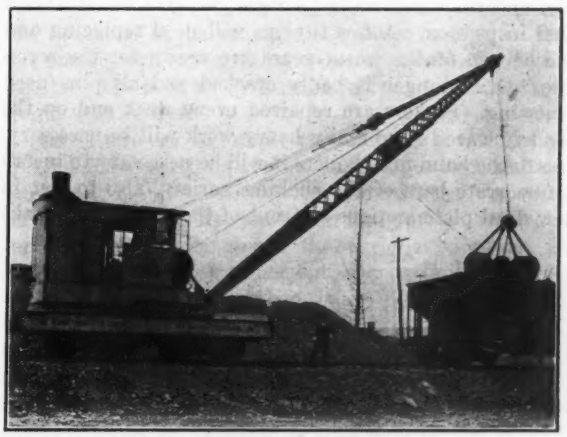


FIG. 1. START IS MADE AT THE COAL STORAGE PILE

a big air leakage obtains. By carefully filling this space with asbestos wool and rope the CO_2 content would immediately jump from five to seven points.

Modern practice of slinging horizontal tubular boilers from structural steel has made air infiltration easier to handle. A good insulation of asbestos next to the boiler allows for expansion and relieves the setting of the boiler weight, thus lessening the cracks. At this time it is well to emphasize the fact that if you are getting lax in the CO_2 end of the game it is well to wake up. If your hand Orsat has leaky cocks and a few other minor ills, repair it. A small plant can make worse investments than having two hand Orsats on hand. In the large plant a hand machine working properly is far superior to an automatic which is dead but not interred.

While we are still doing brick and plastic work, we must thoroughly inspect and repair all baffles. If there is one thing that should commend the horizontal return tubular boiler to the poor overworked boiler operator, it is the absence of baffles. Casey says, "It's them we eat in England for breakfast but they's made of dough instead of fire clay."

Whereas years ago all baffles were made in tile form and quite similar to the cross word puzzles of today, now a large part of the baffles are monolithic. A form is placed between the tubes and the plastic cement poured or pounded in place, making a very clever wall and also an efficient baffle. In the water-tube boilers where horizontal baffles are still used, a refractory tile is used in some passes and cast-iron plates in other passes. It goes without saying that the efficient water

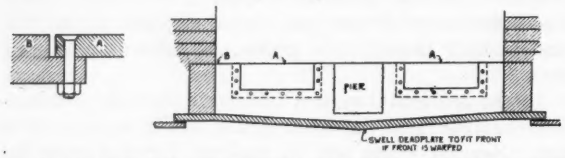


FIG. 2. DEAD PLATE WITH REPLACEABLE SECTIONS IN FRONT OF FIRE DOORS IS ECONOMICAL

tube boiler must be properly baffled with no short circuits allowed to exist.

Now that we have the furnaces in shipshape condition and the outer walls all right, we give the stokers a final inspection. A few tuyeres will need replacing and one or two of the worm gears are ready for the scrap pile. One plunger is badly cracked and all pins need renewing. Stokers are repaired every week end on the dead furnaces so no really heavy work will be necessary.

On the hand-fired boilers it will be necessary to install a few grate bars of the shaking variety, also to put in new dead plate sections in front of the doors. We make

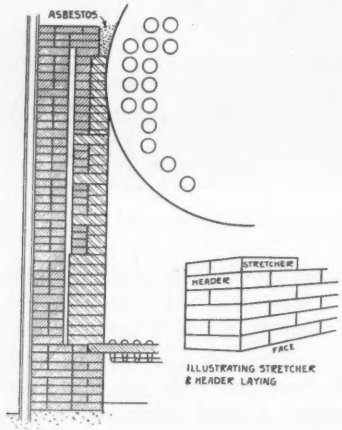


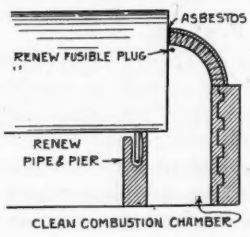
FIG. 3. IT PAYS TO ANCHOR FURNACE WALLS AND PACK FOR POSSIBLE AIR LEAKS WITH ASBESTOS

our dead plates double thickness with cut out places in front of the doors, as those places burn out first. It is then only necessary to take out a couple of bolts, remove the burned sections and replace them, making a lot of unnecessary brick laying taboo.

What's Inside the Boiler?

Next comes the inside of the boiler. We get out the compressed air tools and drill the tubes. This process is gone through twice a year thoroughly and several more times partially, that is the bottom four or five rows are drilled every six weeks, but the full bank drilled only twice a year. Drilling tubes serves two purposes: in the first place it cleans the tubes of scale or baked sludge and in the second place it serves as a method of inspection. Where the hydrostatic test often fails to show a weak tube, the drill test scarcely ever fails. If a tube gets thin to the point of danger, the air tool will knock a hole through it. It is no uncommon thing to replace two or three tubes after drilling, if the tubes are 10 or more years old. Tools for knocking scale from a return tubular boiler, or in fact any fire-tube boiler, are commonly called torpedoes. If the tubes are not old and too thin, this device works very well and boilers which appear to be clean yield a large amount of scale but, if the tubes are in poor condition, it is time saved to forget the torpedo and retube the boilers in the first place.

After all tubes are pronounced in good condition, we try all braces, stays and reenforcing. The hammer test shows to great advantage in this work and the operator need not be a perfect musician to detect cracked braces or stays. Welding of these parts should never be permitted as tests show that, even though the weld holds true, the material at either side is liable to be damaged and thus break at a lower strain than figured. Cracked or broken braces should be renewed at once.



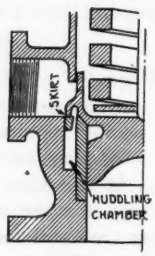


FIG. 4. BACK ARCHES OF RETURN TUBULAR BOILERS SHOULD BE MADE AIR TIGHT AND FUSIBLE PLUGS RENEWED

FIG. 5. IN REGRINDING OR REFACING A SAFETY VALVE, ALLOWANCE MUST BE MADE FOR THE SKIRT, AS TOO LITTLE CLEARANCE WILL MAKE THE VALVE LEAK AND TOO MUCH WILL CAUSE A QUICK BLOW BACK

When we are positive that every possible thing about the immediate boiler has been attended to, we call in the boiler inspector. After a painstaking inspection he remarks, "Why didn't you finish the job and install new fusible plugs?"

Sure enough, we had forgotten to renew plugs. Well, a couple of hours will do that and then the boilers are ready for winter.

Fix the Accessory Equipment, Too

We still have a turbine-driven blower which is thrusting all out of reason and two more blowers which will need inspection. Also the economizer must be drilled. Though the tubes are short, the men do hate this job, for they know that at least a dozen tubes will have to be replaced after the drilling. When we have the turbine on the blower pulled down, that is to say the top half is pulled up, we locate the cause of the excessive thrust. Erosion has taken the corners from the blades of the wheel and the nozzle pressure or velocity or both is pushing the wheel sidewise as well as round and round. The whole wheel and shaft will have to go to the factory for repairs.

While we are working on this job the boss fireman comes along and says, "One of the safeties on number

three will have to come off this week end. She's leaking like a sieve."

Just as we're feeling happy someone has to try to knock the joy out of life.

We always carry a spare safety valve in stock and the change takes but a little while but, in regrinding or refacing this particular type of safety valve, caution must be exercised that the lip or skirt be kept the same distance from the face of the seat after the operation as before or the valve may not seat perfectly, causing extreme leakage. Again, if the skirt is trimmed too short, too quick a blow back will be the result. Our mechanic always uses his feeler and leaves the opening as he finds it after the valve is perfectly ground.

Next we tackle the stoker engines. We find everything in good shape but one crankpin wedge and the governors. The crankpin wedge is readily repaired but the governors are more or less fussy. The air box works on the throttling governors so that, as the steam pressure falls and the forced draft fans speed up or, as the professor says, accelerate, the increased air pressure in the wind box acts on the stoker engines and speeds them up, letting more coal into the stokers and, of course, as the furnace pressure builds up, the uptakes open a trifle to try to maintain, as nearly as practical, a balanced draft. Governor parts are made as light as possible and the work must be as nearly perfect as possible so that all friction may be eliminated, otherwise the work will have been in vain. As we have performed this feat several times before, no doubt is felt as to the outcome.

FIG. 6

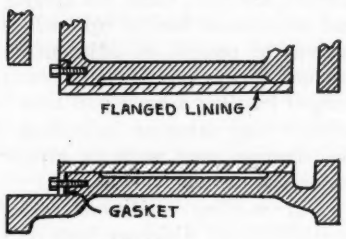


FIG. 7

FIG. 6. ERODED TURBINE BLADES WILL CAUSE END THRUST ON THE WHEEL

FIG. 7. IT IS EASY TO RENEW A PUMP LINING BUT CARE SHOULD BE TAKEN TO HAVE THE JOINT TIGHT BETWEEN THE PUMP AND THE FLANGE OF THE LINING

Heaters and Pumps

We are now getting on the last lap of our inspection and repair journey. There remains only one open and two closed heaters, several pumps of piston and centrifugal type and the ash handling machinery. We will need, without doubt, to pull the lining from one or two duplex pumps and install new hub rings on two of the centrifugal feed pumps. Also the plates in the open heater will need cleaning and possibly some renewing. It looks as though a week or two would be necessary to clean up the trip.

As the centrifugal pumps are staring us in the face, we will tackle them first. Off come the top halves of the split casings and we see what is necessary to be done. Rings on the four impellers will have to be renewed and the bronze sleeves replaced. This means a week on each pump but we are congratulating ourselves that new shafts will not be needed. We may turn the hub on the impeller to the point where it will stand no more turning and then shrink on rings as shown. By this method a set of impellers lasts three times as long as formerly. After the new sleeves are in place (sometimes new spacers between impellers are also necessary) we balance the rotor. First it must be balanced over knife edges for static balance, then it must be rotated between loose centers for dynamic balance. The tendency is toward high speeds, therefore the necessity of balancing. We much prefer to drill out and lighten rather than to counterbalance by adding weight. The hole we drill can't fall out but the counter weight can fall off.

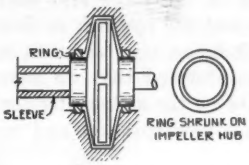


FIG. 8

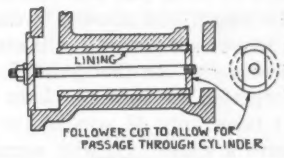


FIG. 9

FIG. 8. PACKING RINGS AND BRONZE SLEEVES WILL PROBABLY NEED RENEWING ON CENTRIFUGAL PUMPS

FIG. 9. IT IS EASY TO PULL THE BRASS LINING OF A PISTON PUMP IF YOU KNOW HOW

Governors on all small turbine auxiliaries are inspected for cracked or broken knife edges and, if found imperfect, are renewed. When pumps are in good repair, the coupling between pump and turbine is checked for alinement. Sometimes the turbine or pump has gotten out of proper alinement and realining is necessary. It would seem when both units are properly doweled to the sole plate that getting out of line would be impossible but someone has remarked that nothing is impossible. Metallic packing of the pump turbines causes us quite some bother. Why is it that manufacturers squeeze the packing in machinery to the point of hysteria? Why do they cut the depth of stuffing-boxes to the extreme minimum? Why do they pack shaft boxes with imitation stuffing-boxes and why six or eight times more? That is why you and I get out our own drawings and make our own parts many times. Every time I have to repair these units the above thoughts enter my mind and, though I am an optimistic individual, my feelings at times are unprintable.

Now we will tackle the piston type pumps. The large simplex pump has a cast bronze sleeve or lining and as this has become more or less cut by gritty water, we will simply remove the flange bolts and by inserting a copper bar through a hand hole tap the end of the lining and remove it with but little trouble. The small boring mill will take this casting easily and a heavy chip followed by a finishing cut will, in a few hours' time, make the lining as good as new. We have a casting for an oversized piston and follower and shortly the pump is ready to be assembled. The auxiliary slide valve needs just a little touching up as the seat is becoming a trifle rounded but this job is soon over. Really I think this pump improves with age.

Pulling the lining from the duplex pump is somewhat of a stiffer job. This lining is nothing more than heavy drawn brass tubing. A professional pump man will not draw the lining. He will take a chisel and split

the lining then crimp it in and remove it with one hand. If he cuts the cast-iron cylinder while doing this job, it will be perfectly all right with him, as the pump belongs to you. By using the follower plate turned a fraction less in diameter than the external diameter of the lining so that it will just slide in nicely to the lining and then planing off the two sides to a trifle less diameter than the lining, we can pull the lining out nicely. It is unnecessary to force this tubing into the cast-iron cylinder full length. If the tubing is draw filed or even put between cones in the lathe and half the length just allowed to clean and the rest left so that a five or six-ton pull will send it home, no tighter fit is necessary. At this point I am informed that we have forgotten the sprocket chain drive on the stoker engines. It takes only 45 min. to put on a new sprocket and we have a spare. So why worry?

Some of the ash conveyor buckets are eaten out by the action of the ash and water and will have to be renewed. These were the buckets that were guaranteed rust proof! The doors on the combustion chamber hopper will have to be replaced, the chimney, flues and economizers cleaned out and then I hope we shall be ready for winter.

Though I neglected to state the fact, the flow meters, boiler instruments and other accessories about the boiler have been checked and found all right. Report has just come in that five new plates have been put in the open heater, one ball float repaired and one float valve needs grinding. The closed heater has been tested and found O. K. I am so glad that something has been found O. K.

Oh yes, the last word! "About 35 new sleepers, two frogs and four lengths of rail will be needed to insure our coal supply." We write O. K. on the requisition and heave a sigh.

Good Turbine Foundations Decrease Maintenance

GOOD TURBINE BASES FREE FROM VIBRATION CAN BE BUILT FROM EITHER REENFORCED CONCRETE OR STEEL. PROPERLY BUILT, THEY ARE INSTRUMENTAL IN KEEPING REPAIRS AND MAINTENANCE AT A MINIMUM

GENERALLY CONSIDERED, the foundation is the lowest part of the structure. When, therefore, turbine foundations as usually built are considered, the base proper can be looked upon as the foundation superstructure and the lowest part of the foundation as the substructure or mat upon the support proper for the turbine rests.

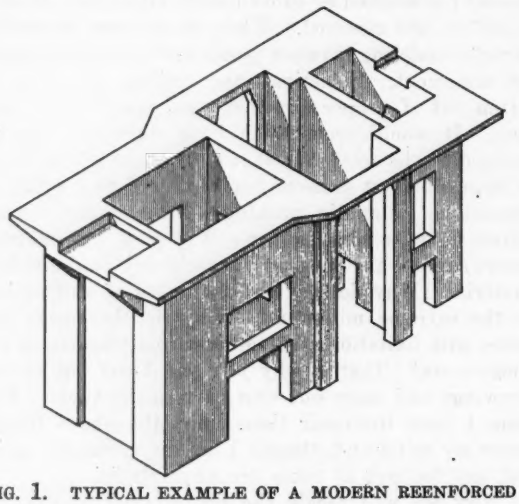


FIG. 1. TYPICAL EXAMPLE OF A MODERN REENFORCED CONCRETE BASE

Regardless of the foundation as a whole the design or construction of the substructure is influenced largely by the foundation of the power house both because the design of both is determined by the same factors and because the foundation of the entire plant will ordinarily be considered and determined before the individual units are considered.

In determining the kind of foundation, that is substructure, to be used the engineer must take into account several factors and conditions. These conditions include the magnitude and distribution of the load to be supported, the depth of a suitable bearing material, the nature of the material above this stratum, the water level at the site, the surrounding conditions, the economy of construction and the design of the plant.

Although the first of these conditions is usually quite definite, the next three are largely matters of judgment and experience, backed up with ground explorations by borings or records of adjacent substructures. Borings are not always positive and results from them must be judged hastily; a hard pan may have soft streaks, or a boulder may cause an indication of rock. Furthermore the stratum may vary in supporting powers, as with water the content varies.

Surrounding conditions as influencing the relative availability of different materials and the economy of construction are relatively unimportant for the reason that the foundation is such a small part of the total cost of the power house that the relation of the foundation to the design as a whole is of greater importance than the slight element of economy which might be involved in its construction.

SPREAD FOOTING IS COMMON TYPE

With a good clay or gravel, the spread footing principle may be applied satisfactorily. This consists of a pad of concrete under each column of sufficient area to distribute the loading of that particular element of the building widely enough to permit the column to support it without undue settlement. When the soil at the bottom of the footing has not sufficient carrying capacity and it is inadvisable to excavate to deeper strata, pile footing may be used. These pilings may be driven only under the footing and a spread footing used, or they may be driven under the entire building area and a reenforced concrete mat placed under the entire structure. This is a satisfactory method of construction where soil conditions are not uniform as any settlement which takes place must be more or less uniform over the entire building. Sometimes a reenforced concrete mat is laid down without the piling support underneath, and occasionally excavation is carried down to bed rock and the mat placed directly upon the rock base.

Where bed rock is too far below the ground surface to have the entire area excavated, concrete piers extending down to this bed rock may be used. These piers are sunk either by the open caisson, pneumatic caisson or a combination of the two methods, depending upon the soil conditions. The open caisson method is the more economical, while the pneumatic caisson method offers the greater security. In the combined methods, the caisson is sunk as far as desirable by dredging, then an air deck is put in and with the lower part converted into an air-tight working chamber the excavation is finished.

Rarely are two foundation cases alike. Each foundation is a separate problem and each type of construction has its particular field of utility and economy.

Steel Base Has Been Widely Used

Steel superstructures or bases are used exclusively by a number of companies, particularly for the larger units. Figure 2 shows an elevation of a typical base of this kind for a 30,000-kw. unit. Vibration which was one of the major arguments against this type of construction has been satisfactorily taken care of. The vibration of a turbine foundation has, of course, its origin in the machine itself and the base must be designed so as to minimize and dampen these disturbances. This means that columns must be cut square, all rivets of first quality carefully driven, the weight properly distributed and the bracing correct. Sometimes the columns are filled with concrete to dampen the vibration

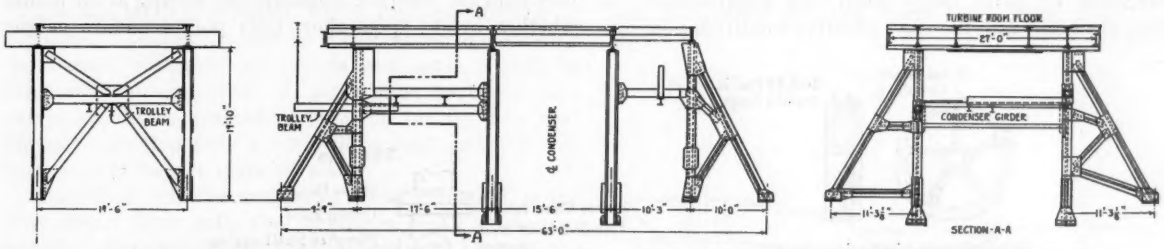


FIG. 2. STEEL BASES HAVE THE ADVANTAGE OF GIVING ADDITIONAL SPACE UNDER THE TURBINE

Reenforced Concrete Base Was Formerly Used Exclusively

The turbine foundation superstructure, or turbine base proper, may be erected directly upon the power house foundation if the mat type is used, or it may be made as a separate unit entirely isolated from the building. This base may be either of reenforced concrete or of steel construction, although in modern plants the latter type is the more popular because of the additional space available beneath the turbine, for generator air coolers and extraction heaters. A typical reenforced concrete base under a 20,000-kw. unit is about 45 ft. long, about 23 ft. wide and 23 ft. 6 in. high, and contains about 344 cu. yd. of concrete. The amount of

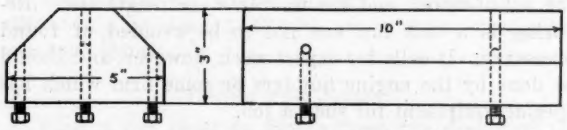


FIG. 3. SOLE PLATES GROUTED IN THE TOP OF THE FOUNDATION TAKE THE PLACE OF A BEDPLATE

reenforcing steel in tension used in tying the base to the wall below is about equal to the weight of the base and consists of 1-in. and 1¼-in. square twisted medium steel. Removable anchor bolts and 4-in. galvanized iron conductor pipe used as sleeves were spaced by means of a wooden templet. Each foundation should be poured as a continuous operation and the form work should be well braced. The base shown in Fig. 1 is a recent design of reenforced concrete. It is for a 20,000-kw. unit, 48 ft. long, 23 ft. wide and 24 ft. high and contains 205 cu. yd. One large opening under the barrel of the turbine can be provided for use with the various piping or a few floor thimbles properly grouped can be substituted, making a more convenient arrangement and neater appearance of the floor.

and occasionally the entire structure is encased in concrete.

Sole plates are used to advantage by the Detroit Edison Co. and they describe the setting of them as follows: "The tops of all bases, both concrete and steel are left about 6 in. low in numerous spots for the location of sole plates. First a thin plate about 6 in. wide and 12 in. long is grouted in at the various locations, then a sole plate casting about 10 in. long, 5 in. wide and 3 in. wide at the top and about 3 in. thick, supported by three jack screws is set on this plate." The design of these castings and the location on a 20,000-kw. unit are shown in Figs. 3 and 4. The castings are machined, put in the store room until needed and then remachined, so as to correct any warping or distortion of the casting which may occur. "By means of a good spirit level, one corner of the casting is brought to exact grade and the casting leveled by means of a machinist's level and the jack screws. If a check by the spirit level shows it to be correct, the sole plate is immediately grouted in." About 45 of these plates are used for a large size unit. For aiding in the alinement of the unit, small lead blocks are set in the floor, one at the steam end and the other at the generator end and the center line of the unit marked on them.

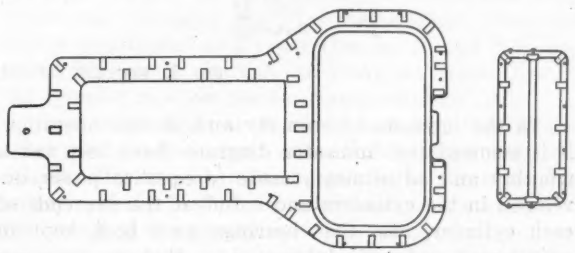


FIG. 4. WITH A LARGE UNIT SEVENTY OR EIGHTY OF THESE SOLE PLATES MAY BE USED

Engine and Condenser Reconditioning

Good Fit of Bearings and Valves, Alinement, Valve Setting and Condenser Joints Promote Economy. By David Alexander*

AS TYPICAL of industrial installations and involving all operations required in reconditioning any engine plant, the case of a condensing Corliss engine will be considered. This is a cross-compound, 20 and 36 by 42 in. with jet condenser and it is assumed that the time has come when a thorough overhauling is desirable. Minor repairs and adjustments to bearings and valves have been made, from time to time as needed, generally during week ends to avoid shut downs, but general wear makes desirable a full reconditioning, replacement of parts badly worn and readjustment to bring the plant into the most effective condition possible.

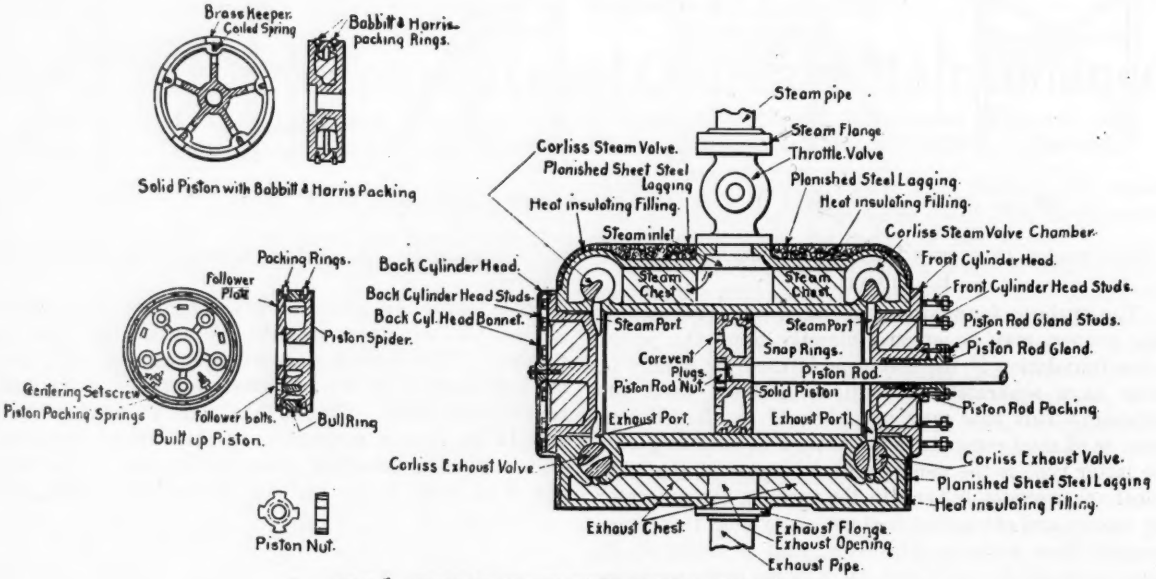


FIG. 1. SECTION OF CYLINDER, PISTON AND VALVES

In the interests of economy and smooth operation, it is assumed that indicator diagrams have been taken monthly and adjustments made to equalize power developed in the cylinders and cutoff at the two ends of each cylinder, also that bearings have been kept in adjustment and well lubricated so that no extensive replacements or rebuilding are anticipated.

First Dismantle and Examine All Parts

Begin with the cylinder, taking off the head with a chain block and examining around all bolt holes for indication of cracks starting. It is a good plan to clean each piece thoroughly, as it is removed, inspect it for wear and any indications of failure, tag it with work to be done on it and pile it where it will be safe from injury and near to related parts. This will simplify procedure, insure that no needed work is overlooked and speed up reassembling.

Turn the engine until the piston is at the head end. Take out follower plate bolts and remove the plate with the chain block. Loosen the locknut holding piston rod to crosshead and unscrew the piston rod from crosshead. Next take out the piston rod gland, remove packing from stuffing-box, take the nut off the piston rod and remove piston and rod from the cylinder. The piston should be left on the rod but packing rings and springs and bull ring should be taken off and examined, badly worn rings and broken or weakened springs being marked for replacement. All parts, after cleaning and examination, should be wrapped or covered in piles to protect from dust and dirt.

Now is a good time to inspect the cylinder, noting its condition, whether it has an oily feeling at all points. whether bright spots show high points and to caliper for out-of-round and for uneven wear lengthwise. Reboring is a task but one not to be avoided, if found necessary. It calls for expert work, however, and should be done by the engine builders or some firm which has special equipment for such a job.

Connecting rod can now be dismantled, by easing up brasses at the crosshead end, then loosening and driving out the crosshead pin with a piece of wood and a sledge; at the crankpin end by removing adjusting bolt and wedges, then sliding out the brasses. This will let the rod free and brasses can be taken out of the crosshead end, if inspection shows it to be necessary.

Crosshead shoes can next be removed and the crosshead taken out of the guides, after which shoes should be replaced on the crosshead and calipered to make sure that surfaces are parallel and without excess wear at the ends. Also guides should be calipered for the same purpose.

Eccentric straps, both steam and exhaust are taken off, also eccentric rods, governor belt and governor rods. Usually the governor can be gone over in place to test for lost motion and take up wear without removing from the engine. Its dashpot should be cleaned out and

*Chief Engineer, The Congoleum Co.

filled with fresh oil but entire dismantling is not necessary.

Again the caution, clean each piece as removed, inspect carefully, note any work needed, pile in order and protect from dirt and damage.

Main and outboard bearing caps come off next, quarter boxes are taken out and the shaft is jacked up so that a line can be run through the centers of the bearings, in order to square up the shaft. Quarter boxes will have to be replaced when squaring up and it is desirable to have bearing caps in position, hence it is wise to jack the shaft up to allow this.

Valve gear can now be taken down by removing wristplate rods, uncoupling dashpot rods, unbolting bonnets and withdrawing bonnet and valve together. Unless lost motion is found, which requires bushing or adjusting bearings, it may be unnecessary to dismantle the bonnet assembly but valves and seats should be examined and calipered. If seats must be bored, new valves should be ordered, a close fit for the new seat diameters so that only a little filing and scraping will be necessary to put them in place.

Boring of cylinder and valve seats, if needed, is the next step. This calls for rigging a small engine or motor to drive the boring bar and means to support the bar central and to drive it forward while taking the cut. Be sure that the cylinder is level and all anchor bolts and frame bolts tight before starting. The work must

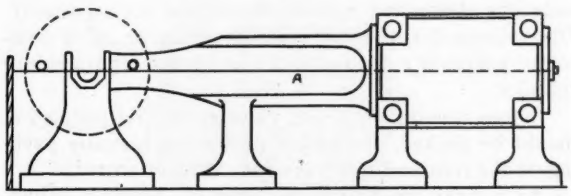


FIG. 2. STRETCHED WIRE FOR SHAFT AND CYLINDER ALINEMENT

be done with extreme care and the least possible amount of metal removed. After boring, all metal dust and dirt should be cleaned off with air or steam blast, after careful wiping.

Lining the Engine

First a line must be gotten from the center of the head end of the cylinder to the center of the shaft as shown in Fig. 2. A piece of fine wire is put through a stiff strip of wood which is long enough to span the cylinder flanges and be held in place by flange bolts. The wire is carried to a support placed beyond the shaft and fastened so that the wire can be shifted vertically and horizontally until it is in the exact center of the cylinder at each end. A stick with a sharpened nail in each end, the distance between nail points being the radius of the cylinder, is convenient as a caliper for the head end and the crank end can be centered in the stuffing box by calipers. The wire should be stretched tight to avoid sag. The line, when centered at the cylinder ends, should be at the height of the center of main bearings and, of course, central in the guides, if the engine is in line. If not, the guides and boxes must be shimmed until alinement is obtained. Cylinder and guides should, of course, be level as well as in line and rechecking should be made before the work is considered complete.

Squaring Up

Squaring the shaft is next and should be done with main and outboard boxes in place. A line is run to supports so that it can be centered in main and outboard bearings as in Fig. 3. It should be level and at the same height as the center line. To test for square, use a piece of wood 6 to 8 ft. long with ends sharpened as shown and a mark at the exact center. Place the center mark at the bearings line and tie a string on the cylinder line at each end. From one string measure to the bearing line and mark. Measurement from the other string should come exactly to the same mark. If not, bearings must be shifted sidewise until their center line is squared up, also raised or lowered until it is level.

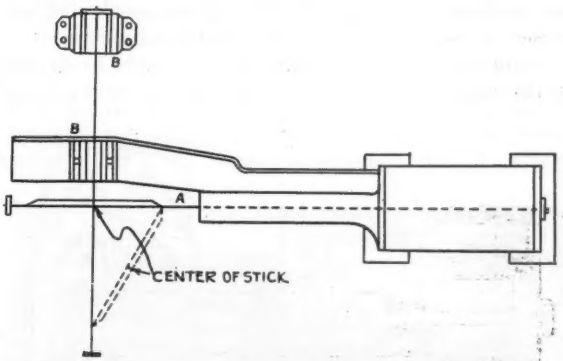


FIG. 3. LINE THROUGH BEARINGS SHOULD SQUARE WITH CENTER LINE

If rebabbiting of boxes or fitting to the shaft is needed, it should be done before the squaring up, as the shaft is to be lowered into boxes next, so that the crank and crankpin may be checked up. Bearings should be adjusted to an easy running fit and it is customary to set the shaft $\frac{1}{32}$ in. above the center line of the cylinder to allow for wear and settling.

Squareness of the shaft can be tested by turning the crank pin nearly to head and crank centers, when the cylinder line should, in each case, be at the same distance from the face of the crank and at the center of the length of the crankpin.

Crosshead Adjustment

Meantime, if speed is desired, the crosshead pin can be calipered for uneven wear and, if a light cut only is needed, it can be taken in a lathe and new boxes fitted. If in bad shape, a new pin should be ordered. The crosshead can now be placed in the guides and the piston assembled and placed in the cylinder, first giving the cylinder walls and crosshead guides a liberal coating of oil. It is best to use new follower plate bolts in the piston to guard against crystallization. Screw the piston rod into the crosshead and adjust the shoes until the rod is equidistant from top and bottom guides. Then tighten the jam nut lightly.

Test the crankpin for roundness and equal diameter throughout its length. It can usually be trued up, if needed, by filing, scraping and polishing. Boxes should, of course, be fitted carefully.

To test alinement of the crankpin, put on the con-

necting rod and key it up snug, leaving the crosshead end free and supporting it by a stick resting on the guides. Push the crosshead back to the head end out of the way. Turn the crank near head and center and put slight sidewise pressure on the other end of the rod. Measure the distance from face of crank to inside edge of crankpin brasses. Turn the crank to the other center, press the rod in the same direction and repeat the measurement which should be the same as before. Small errors can be remedied by filing and scraping the pin.

To test for square bore of brasses, key up the crankpin brasses snug and measure from edge of crosshead guide to side of connecting rod end. Disconnect from crankpin, turn the rod 180 deg. so that the other side is up, connect again, key up and repeat the measurement. The two should agree, if brasses are properly bored. Crosshead pin brasses can be tested in like manner, leaving the crankpin end disconnected. If not correct, chipping, filing and scraping are in order.

Alinement of the crosshead pin is tested by keying up the connecting rod to that pin, leaving crankpin end

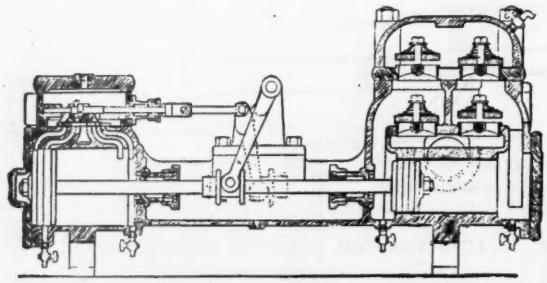


FIG. 4. SECTION OF DUPLEX CONDENSER PUMP

free. Place crankpin in four quartering positions, at centers, top and bottom, with connecting rod resting on it. In each position, the end of the connecting rod should be the same distance from each end of the crankpin.

In final adjustment of crosshead and crankpin brasses, it is usual to pull up snug by means of the adjusting bolts, then back off say ½ turn to give a running fit. Be sure that the jam nuts or bolts are set up tight so as to hold brasses firmly in position and prevent working loose.

Valve Gear

Dashpots should be examined for smooth, quick action, the pots should be taken out, cleaned and the fit noted at the point of entering the cylinder, as no air should enter or escape at this point. The pet cocks should be adjusted until the plunger works rapidly but without slamming.

For the link rods, steam hooks, governor rods and wristplate, usually little work is required but they should be examined and new bushings, collars or pins supplied as needed.

Valves and bonnets may be replaced, eccentrics and rods, dashpots, governor rods and wristplate rods connected and the cylinder head put in place.

Check up of mechanical clearance should be made by disconnecting the connecting rod from crosshead, moving piston and crosshead back and forth and marking on the guides striking points positions for one end of the crosshead. Connect up the rod, turn the engine over and mark the stroke limits for the same end of the crosshead. If distances between striking points and stroke limits are unequal, loosen jam nut on piston rod and screw piston rod into crosshead by half the difference, if the crank end distance is larger, or out of crosshead, if head end distance is larger.

With governor on the safety stop, adjust so that valves will not unhook when the wristplate is worked by hand. When governor is at extreme upper or lower position, valves should not hook up when wristplate is worked. Dashpot rods should be adjusted so that hooks do not strike when dashpots are down.

Valves can now be set. With back bonnets off, place the engine on head end center and the wristplate vertical. Loosen the eccentric and rotate about the shaft, adjusting the eccentric rod so that the rocker arm swings equally each side of the vertical, then the hook rod so that wristplate travels likewise.

With wristplate vertical, adjust steam and exhaust valve rods to give valves proper lap as indicated by marks on the back end of valves and seats, about ¼ in. steam lap and ⅛ in. exhaust lap. Hook up the wristplate and move the eccentric to give about $\frac{1}{16}$ in. steam lead on the head end valve, then make eccentric fast on the shaft. It is well to bar over the engine and check up all valves for lap and lead.

For a double eccentric engine, the method is the same but steam and exhaust valves are set separately. The process for the low-pressure cylinder of a compound engine is a duplicate of that on the high-pressure cylinder.

Before turning on steam, valve stems and piston rod should be packed, the writer preferring metallic packing, if the rods and stems are not pitted or scored.

As a final precaution, go over all bearing adjustments and nuts to make sure that everything is in shape and tightened up securely. Then steam may be blown through to warm up, a liberal supply of oil turned on and the engine turned over. It is better to run idle slowly for a day or so to wear in new bearings. Before putting in service, take indicator diagrams to check valve setting and make any needed adjustments.

While the work on bearings is going on, the oiling system should be cleaned, blown out with air, washed out with kerosene and filled with fresh oil.

Condenser Plant

With the jet condenser, a piston valve pump is used to maintain 28 in. vacuum. The pump has 12 valves and springs in the water end which is fitted with a bronze liner. Pump and condenser should be opened up and all valves, springs and cylinders examined for tightness and general condition. Springs should be tested for tension and all should be nearly alike. Any showing weakness should be replaced so that each valve will do its share of the work.

Valve seats should be gone over and bad ones replaced, also valves which do not seat tight. Medium hard rubber valves are best. Seats should be screwed firmly in place, or forced in and beaded over on the under side to prevent coming loose.

If the liner is worn or cut by gritty water, a new sleeve is needed. The old one is pulled out by long bolts

and the new one forced in by the same method or by hydraulic pressure, then the ends expanded to make it fast against movement with the piston.

Go over the pistons and rods for scoring, unevenness or springing, and make sure that pistons are tight on the rod.

Connections for operating the steam valves become worn after a time and, if much play is found, bushings and new parts should be supplied, otherwise the pump will run noisily and with considerable slip.

Steam cylinder and chest may need reboring and a new valve or piston rings. Soft packing is usually used on the water end, sometimes with springs to force it against the liner. New packing, and, if needed, new springs should be fitted. Stuffing-boxes should be repacked, metallic packing being preferred by the writer for the steam end.

As to the condenser, leaks are the chief difficulty, air leaks being especially troublesome. Glycerine and litharge will generally stop them, a candle flame being a good means of locating them.

Baffle plates should be cleaned and, for a surface condenser, tube sheets and tubes also, although such cleaning should be a part of operating routine. Joints of tubes in plates should be tested by water pressure and made tight.

Reassembling is simple and hardly needs comment but connections from condenser to engine and stuffing boxes on the low-pressure cylinder should be gone over for air leaks, which are an active enemy of good vacuum.

Developments in High-Speed Diesel Engines

NEW LINE OF F-M DIESEL ENGINES IN SPEEDS RANGING FROM 500 TO 800 R.P.M. AND RATINGS FROM 30 TO 180 HP. SHOW TREND IN DESIGN

IN MANY PLACES in the power field the application of Diesel engines has been limited by the space occupied and weight of this type of prime mover. Due to the high thermal efficiency and low operating cost of the Diesel engine there has been considerable demand for lighter weight, higher speed engines of a compact design suitable for such service as power shovels, locomotive type cranes, and similar service. Then also there has been a demand for smaller direct and alternating-current units which would permit the installation of Diesel power in present power plants without the enlargement of the power plant building or units of a type which would be similar to a gasoline engine in the simplicity of the installation arrangements.

There have been a number of developments of Diesel engines to meet this demand, one of the most interesting being the recent announcement of an extensive line of higher speed, lighter weight Diesel engines by Fairbanks, Morse & Co. shown in section in Fig. 1. These engines are of the two-cycle airless injection type and follow in general principle the lines of the larger Diesel engines built by this organization. They have, however, a number of interesting features because of their smaller size and higher speed. The smaller series, in ratings of 15 hp. per cylinder, operating at 800 r.p.m. are built in 2, 3 and 4-cylinder models while the larger series, are built with 30-hp. cylinders in 3, 4 and 6-cylinder models.

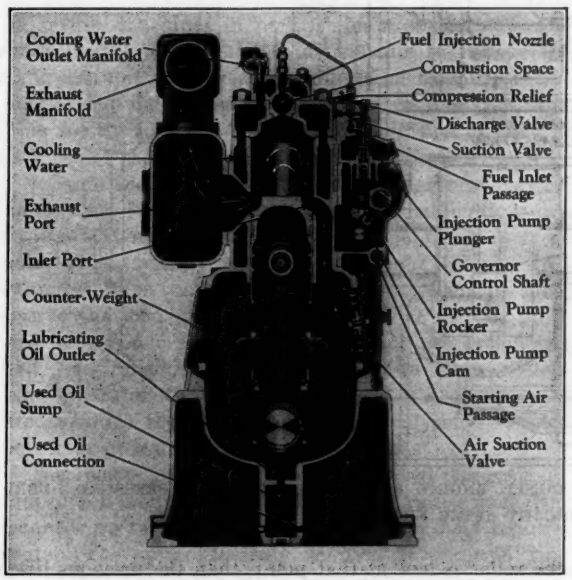


FIG. 1. TRANSVERSE SECTION THROUGH THE BLOCK CYLINDER DESIGN RATED AT 15 HP. PER CYLINDER AT 800 R.P.M. AND BUILT IN 2, 3 AND 4-CYLINDER UNITS

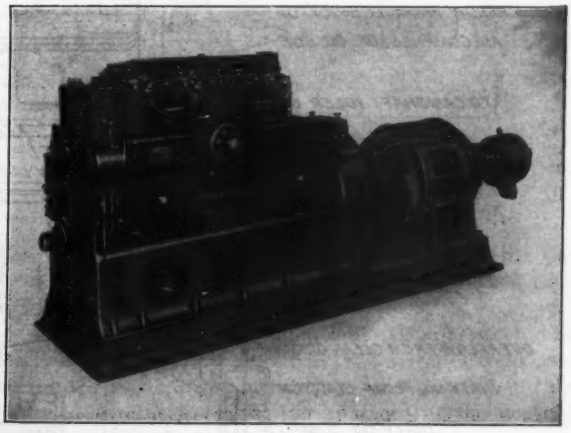


FIG. 2. BLOCK DESIGN F-M DIESEL ENGINE DIRECT CONNECTED TO A 35-KW. 720-R.P.M. ALTERNATOR WITH DIRECT-CONNECTED EXCITER

COMPACTNESS, SIMPLICITY AND RIGIDITY ARE FEATURES

Compactness and simplification of design in the 15-hp. cylinder size is secured by casting the cylinders in block. Water piping is thus entirely eliminated. Rigidity which reduces the weight in pounds per horsepower is thus secured. Small engines are frequently set on foundations which are not rigid. Rigidity of construction then becomes an important factor in maintaining bearing alinements.

In one type, these engines are equipped with radia-

tor cooling and with a built-in clutch of the automotive type for application to mobile equipment. These are also furnished with a pulley or arranged for chain drive as desired. They may be direct connected to such loads as centrifugal pumps. The unit shown in Fig. 2 which is one direct connected to a small alternating-current generator with direct-connected exciter is reported to be the first of this small type of Diesel engine alternating-current generating sets. Since this small engine is as efficient as the large Diesel type the small generating set makes it possible for the power user, who has a comparatively small load, to get the same economy as the largest user of power.

Thorough lubrication and means for straining, filtering and reusing the lubricant are provided as shown in Fig. 3. The air starter and injection cams run con-

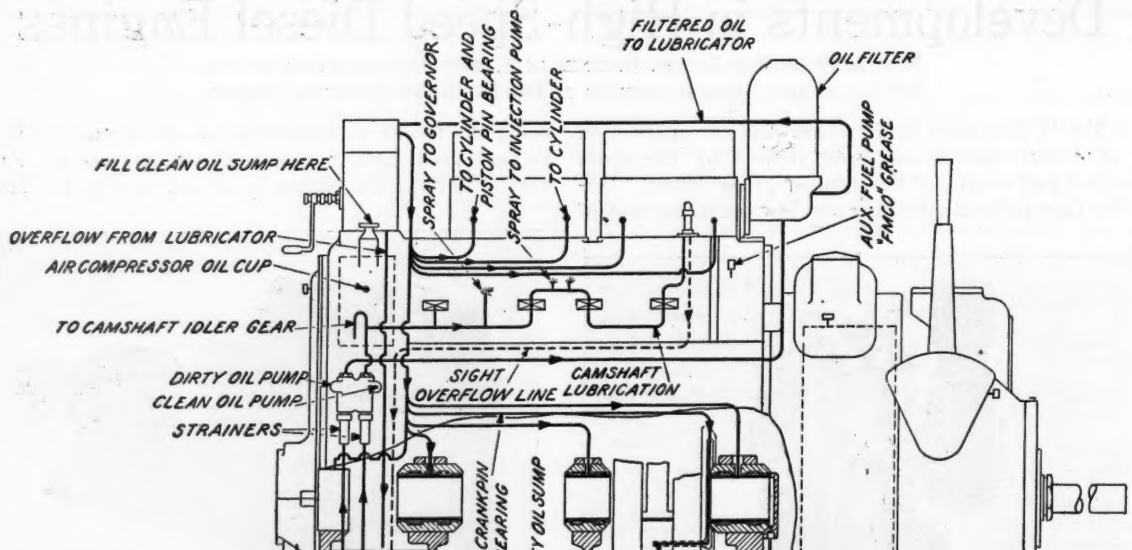


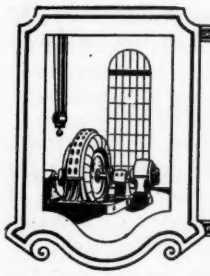
FIG. 3. LUBRICATION SYSTEM OF NEW BLOCK DESIGN F-M DIESEL ENGINE SHOWING METHOD OF PRESSURE LUBRICATION AND REUSE OF LUBRICANT AFTER FILTRATION

tinually in a bath of oil. A mechanical force feed lubricator supplies oil to each power cylinder and piston, each main bearing and each connecting-rod bearing. Excess oil is drained to a common sump and then to the sump at the end of the base from which it is pumped to the filter. Need for replenishment of oil is indicated by a gage glass on the force feed lubricator.

Control of regulation is unusually simple and flexible in these engines, permitting throttling down to a very low speed and sudden speeding up when desired by means of the manual control regulator. No starting control wheel is required as the engine is non-reversing. The engine starts instantly when a quick operating air valve is opened. Speed changes are made by means of a governor control wheel. Provision has also been made for varying the speed slightly by means of a manual control without changing the setting of the governor.

Each cylinder is supplied with an injection pump, the amount of fuel injected being controlled by the length of the injection-pump-plunger stroke. The suction valves are automatic in their operation; that is, they open and admit fuel to the barrel of the injection pump on the down stroke of the plunger. The length of stroke of the plunger is regulated through a simple linkage controlled by the governor. When the engine speeds up, the motion, caused by the lifting of the governor weights, is transmitted to the governor-control shaft. By referring to Fig. 1 it will be noticed that the plunger push rod is inclined at a slight angle, depending upon the amount the eccentric strap has been moved to either side by the turning of an eccentric on the governor control shaft. When the push rod is moved to the left, as the result of an increase in speed, the vertical motion of the rocker when the cam passes under the roller is less, at that point, than the previous lift of the push rod and the length of stroke of the plunger is decreased. This control of the fuel injection is so accurate that the engine regulates closely even under light loads and slow speeds, and will not overspeed when the engine is suddenly speeded up.

Fuel supplied to the suction valves is under a pressure of five pounds. The pressure is obtained by having the gear pump, which supplies the fuel to the auxiliary fuel reservoir on the engine, operate against a spring-loaded relief valve. When the fuel pressure builds up to five pounds, the excess fuel which is pumped by the gear pump overflows back to the main supply tank. By having the fuel under pressure the cylinders of the injection pumps are positively filled on the opening of the suction valves and there is no possibility of the pumps becoming air bound or of not discharging the full amount of fuel called for by the governor setting.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Load Indication by the Current Balance Method

FOR TRANSMITTING INDICATIONS OF LOAD, VOLTAGE, WATER LEVEL, ETC., THIS APPARATUS WILL OPERATE OVER DISTANCES OF 30 MI. BY BERNARD E. LENEHAN*

DURING THE LAST decade there has been a considerable increase in the use of electric power in industry and a correspondingly large growth in the central station industry. Power stations have become larger and interconnection of power stations has led to great power systems. The area served by some of the larger systems involves problems in load dispatching, i. e. dividing load between various stations to obtain the best overall system efficiency, or minimum cost of power delivered. The same problem arose in early power plants containing several machines in parallel on a single load, and was solved by switchboard instruments to inform the plant operator of the load on individual machines. The remote load indicating system described does the same thing for the load dispatcher in keeping him advised at all times of the load on each separate plant.

Remote indicating systems fall into several classes; the simplest division is into manual and automatic types. Manual systems in use range from telephones to large dials set electrically by hand and light signals. All manual systems have the weakness that someone must observe the load and then set the signal for the guidance of someone else. Manual systems are frequently used for transmitting load information from switchboard operator to boiler-room attendants so that the rate at which the fuel is fed may be adjusted to keep the steam pressure steady and avoid waste of fuel.

The remote indicating system described has been developed for the purpose of transmitting indications over distances up to 30 mi., which will include most requirements. The apparatus may be used for transmitting load indications to the boiler room at the same time.

Indication of load or other quantity which is to be measured is transmitted as a small direct current. This operates standard direct-current instruments which translate the current into an indication. The current is originated by a so-called "transmitter" by balancing two forces—one produced by an element which measures the quantity to be transmitted; the other force produced by the transmitted current in another element. This is the origin of the names Current-Balance System and Current-Balance Transmitter.

Transmitters consist of two measuring elements mechanically connected in opposition. The one element is adapted to measure the quantity whose value is to be indicated, while the other is an element to measure small direct currents of the order of 20 milliamperes. The transmitter includes a small-motor-operated rheostat controlled by contacts on the meter elements. This rheostat controls the current, which passes in series through the direct-current element, the rheostat itself,

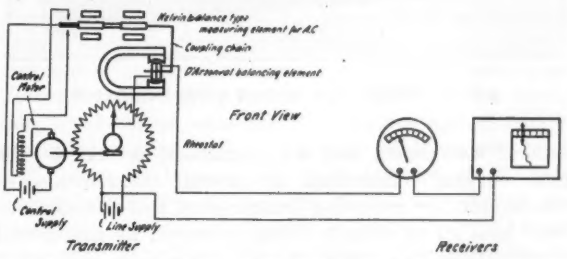


FIG. 1. CONNECTION OF ONE TRANSMITTER TO RECEIVERS CONNECTED IN SERIES

the remote indicating circuit, and remote indicating devices known as the receivers. This is shown schematically in Fig. 1.

Normally a balanced condition exists between the forces exerted by the d'Arsonval type direct-current balancing element and the measuring elements. When this balanced condition exists, the contacts in the control motor circuit are open and a constant current, taken from the supply source, passes through the receiving circuit. The schematic connections shown in Fig. 1 indicate that in case the measured quantity increases it will by exerting additional force, disturb the balance of the elements and cause the upper contact of the transmitter to close. This will allow the control motor to operate the rheostat so that enough additional current is supplied to re-establish the balanced condition, and the contacts open. If instruments are added to the receiving circuit, a similar unbalance will be caused by the decrease of current due to the increased resistance of the receiving circuit. The closing of the upper contact will, in this case, cause the operation of the motor operated rheostat until the potential applied to the receiving circuit is raised sufficiently to restore the current to its former value. Balance being restored, the contact will again open. A like operation takes place when the supply voltage decreases. A decrease in the measured quantity will likewise result in the closing of the lower contact until the current in the receiving circuit falls sufficiently to re-establish a balance. The current passing through the receiving circuit may be a current transmitted by a single transmitter or, in the

*Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

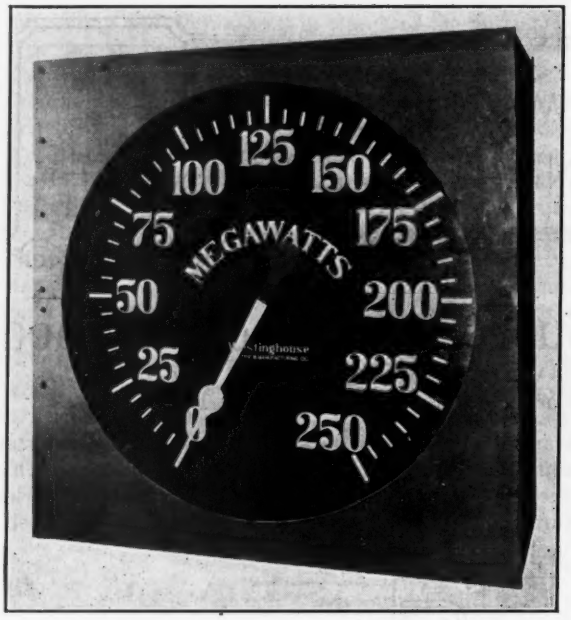


FIG. 2. 60-IN. DIAL BOILER ROOM INDICATOR

case of wattmeters and d.c. ammeters, it may be the total current transmitted by several transmitters, in which case the receiving instruments will indicate the total load on all circuits being measured by the several transmitters.

Receivers Are Standard D.C. Instruments

The receivers are standard direct-current instruments with their scales marked in kilowatts, volts, amperes, water level, etc. They measure the current sent out by the transmitters and thus indicate in proportion to the quantity being measured. These instruments may be of the indicating or graphic type, and several instruments may be used, located as desired, without changing the type or adjustments of the transmitters.

Figure 2 shows a large size indicator for use in boiler-rooms. Such locations make the dust-proof case construction shown a necessity. This instrument has a dial opening of 60 in. and figures 5 in. high. The dial is illuminated by lamps concealed in the case. The figures and scale are clearly readable at 150 ft. The mechanism which operates the pointer in response to the current is similar to that of the transmitter. The measuring element operates contacts which control a small motor which moves the large pointer in response to the current. A smaller size instrument of the same type is used in smaller boiler rooms. These indicators are often used with two hands on the dial, one white to indicate the actual load, and the other red, which is arranged to be set to indicate the load to be expected in the immediate future, so preparations can be made. The red hand is set by the switchboard operator by means of electrical remote control. The relative locations of the pointers on the dial indicate whether the load is or is not changing.

Current values upon which this apparatus usually operates are purposely made small to allow operation over lines of high resistance to distant load dispatching points. The practicable length of line is limited by the line's transmission characteristics and by the maximum voltage applied to it.

Open Line Wires Not Recommended

Transmission over open wire lines is not recommended except in dry climates as the leakage over the insulators of a long line in wet weather is a cause of error. This condition can not be improved by changing the operating value of current transmitted; increasing the current merely increases the drop on the line which requires more voltage to get the current through. More voltage means more leakage. Cable lines are much better as they are little affected by weather conditions. If we define the transmission limit as that distance which causes an error of one per cent due to line characteristics, the limit for standard No. 22 gage telephone cable is around 22 mi. The limit of No. 19 gage cable is roughly 30 mi. The usual voltage limit of such cables is about 80 v. which would be obtained in a line 22 mi. long of No. 22 cable with 20 milliamperes in the line. This fixes the maximum current for extreme transmission. Larger currents can be used for shorter distances.

The same transmitters may be used for sending indications to the boiler-room and the load-dispatcher, by looping the receiving circuit through the various places. Where the line to the dispatcher is subject to interruption at times, or to leakage trouble in wet weather, it may be desirable to use an extra direct-current transmitter to repeat the current in the plant circuit to the outside lines. This will prevent outside line trouble from affecting the plant circuits.

In principle the current-balance is not limited to indication of power. Other electrical quantities can

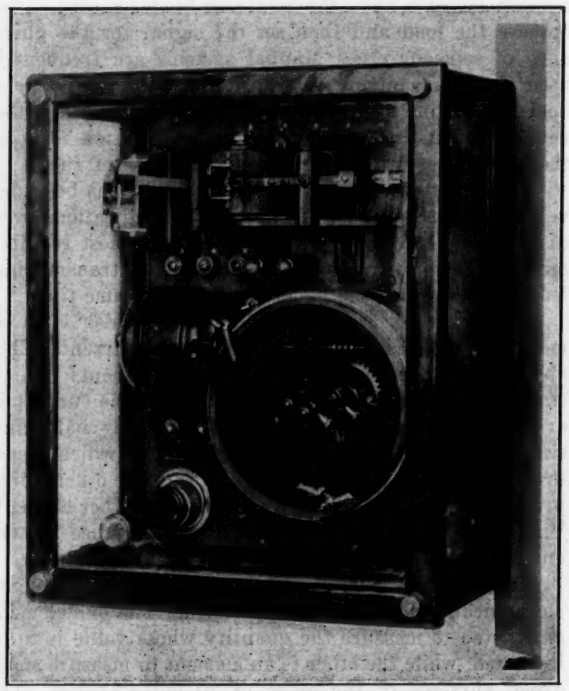


FIG. 3. CURRENT BALANCE TRANSMITTER

also be transmitted, such as current, voltage, reactive voltamperes, power factor, and voltamperes. The last two mentioned require two transmitters and a three-wire circuit to provide separate transmission of power and reactive voltamperes. The position of a mechanical member such as a float can also be transmitted by a variation of the method. The position of the float changes the tension on a small spring which acts upon the element. The tension of the spring is neutralized by the forces due to the current just as the pull of the wattmeter element was neutralized in the wattmeter transmitter. This device can also be used to indicate gate openings or other similar mechanical positions.

Several of these transmitting outfits are installed in various parts of the country for indicating load in steam power plants and water level in hydro-electric plants, and for transmitting instrument readings of unattended substations to the distant operator and for various other purposes. One of the most recent applications is the use with supervisory control outfits for giving selective indications of the load on various feeders at an unattended substation.

The Care of Motor Insulation*

RELATIVE TO LUBRICATION, CLEANING AND DRYING OUT, INSPECTION AND METHODS OF TESTING

MODERN METHODS of design and construction have made the electric motor one of the least complicated and most dependable forms of machinery in existence, and have thereby made the matter of its maintenance one of comparative simplicity. This statement should not, however, be taken to mean that proper maintenance is not important; on the contrary, it must be given careful consideration if the best performance and longest life is to be expected from the motor. The two major features, from the standpoint of their effect upon the general performance of the motor, are those of proper lubrication and the care given to the insulation, because they concern the most vital, and probably the most vulnerable, parts of the machine. The former will be discussed here only with regard to its relation to the maintenance of the insulation.

LUBRICATION

Designs of bearings and bearing housings of motors have been wonderfully improved in the last few years. The point has now been reached where bearings of modern motors, whether sleeve, ball, or roller, require only very infrequent attention. This advance in the art is not yet fully appreciated, for, while there may have been some necessity for more frequent attention in the case of older designs with housings less tight than on modern machines, oiling and greasing of new motors is often entrusted to uninformed and careless attendants, with the result that oil or grease is copiously and frequently applied to the outside as well as the inside of bearing housings. Some of the excess lubricant is carried into the machine and lodges on the windings, where it catches dirt and thereby helps in the ultimate failure of the insulation.

Modern designs provide for a plentiful supply of oil or grease being held in dust-tight and oil-tight housings. If the proper amount of a suitable lubricant is applied before starting, there should be no need to refill the housings for several months, even in dusty places. Infrequent though periodic and reasonable attention to modern bearings of any type will tend toward longer life of both bearings and insulation.

Motors should be stored in a dry, clean place until ready for installation. Heat should be supplied, especially for larger high-voltage machines, to protect against alternate freezing and thawing. This is equally applicable to spare coils.

Motors that have been long in transit in moist atmosphere, or have been idle for an extended period without heat to prevent the accumulation of moisture, should be thoroughly dried out before being placed in service. Machines may also become wet by accident, or they may "sweat" as a result of a difference in their temperature and that of the surrounding air, just as cold water pipes "sweat" in a warm, humid atmosphere. This condition is, of course, exceedingly injurious and should be prevented, particularly in the case of large or important motors, by keeping them slightly warm at all times. Current at a low voltage can be passed through the windings, electric heaters can be used, or even steam pipes may be utilized for protective purposes. In the case of extended idle periods, tarpaulins may be stretched over the motor and a small heater put inside to maintain the proper temperature.

If a motor has become wet from any cause whatever, it should be dried out thoroughly before being operated again. The most effective method is to pass current through the windings, using a voltage low enough to be safe for the windings in its moist condition. For 2200-v. motors, 220 v. is usually satisfactory for circulating this drying-out current. Thermometers should be placed on the windings to see that they are being heated uniformly. Temperatures should not exceed 90 deg. C. (Class A insulation). Applying the heat internally in this manner drives out all moisture and is particularly effective on high-voltage motors, where the insulation is comparatively thick.

Heat may be applied externally by placing heating units around or in the machine, covering the whole with canvas or other covering, and leaving a hole at the top to permit the escape of moisture. In doing this, it is essential that there be a circulation of warm air over all the surfaces to be dried. The air should be allowed to escape as soon as it has absorbed moisture; therefore, the heaters should be so placed and baffles so arranged as to get a natural draft; or small fans may be used to force circulation. Twelve-inch fans set to blow air across the fronts of "glow heaters" and then into the lower part of a machine from opposite sides, and so on up around the windings and out the top, will produce surprising results. The temperature of the winding should not be allowed to exceed 100 deg. C. for Class A insulated motors. Smaller machines may conveniently be placed in ovens, the same temperature limits being observed.

*Abstracted from an article by C. W. Falls in the General Electric Review.

Insulation Resistance Tests

Time required for complete drying-out depends considerably on the size and voltage of the motor. Insulation resistance measurements should be taken at intervals of four or five hours until a fairly constant value is reached. This value should at least equal the recommended A. I. E. E. Standard, which is

Megohms = (Voltage) ÷ (Kv.a. + 1000)

The insulation resistance of dry motors in good conditions is considerably higher than this value.

The more convenient way to measure this resistance is through the use of a "Megger," although if a 500-v. d.c. source is available, readings can be taken with a voltmeter. The ungrounded side of the system should be connected to all the motor terminals through the voltmeter, the opposite or grounded side being connected directly to the motor frame. The insulation resistance is found by

$$R = r\left(\frac{E}{V} - 1\right)$$

Where R = insulation resistance in ohms, E = line voltage (d.c.), V = voltmeter reading, r = resistance of voltmeter.

In using the voltmeter method the connection to the frame should always be made through a fuse of not more than 10 amp. in size. The circuit should be tested and the side showing a complete or partial ground then connected to the frame through the fuse.

Obviously the insulation resistance varies over a wide range, depending upon moisture, temperature, cleanliness, etc., but it is a good indication of the general condition of the insulation and its ability to stand the operating voltage. Such readings should be taken before a high-potential test, to determine whether the insulation is ready for such a test, and afterwards to make sure that the high potential has not injured the insulation.

High-Potential Tests

High-potential tests should be made after drying out, or after repairs, to determine the dielectric strength of the insulation. New windings should successfully stand a high-potential test of twice normal voltage plus 1000. There is some disagreement as to the proper value to use for motors that have been in operation for some time, but it is reasonable to assume that, after thorough cleaning and drying, the winding of a used motor should stand 150 per cent of normal voltage for one minute. Small high-potential testing sets are available for such work and are of such capacity that very little damage will result from a breakdown during the test.

Periodic Inspection

A systematic and periodic inspection of motors is necessary to insure best operation. Of course, some machines are installed where conditions are ideal, where dust, dirt, and moisture are not present to an appreciable degree; but most motors are located where some sort of dirt accumulates in the windings, lowering the insulation resistance and cutting down creepage distances. Steel mill dusts are usually highly conductive, if not abrasive, and lessen creepage distances. Other dusts are highly abrasive and actually cut the insulation in being carried through by the ventilating air. Fine cast-iron dust quickly penetrates most insulating materials. Hence, the desirability of cleaning the motors periodically. If conditions are extremely severe, open motors might require a certain amount of cleaning each day. For less severe conditions weekly inspection and partial cleaning is desirable. Most machines require a complete overhauling and thorough cleaning about once a year.

For the weekly cleaning the motor should be blown out, using moderate pressure, dry, compressed air (of about 25 to 30 lb. per sq. in. pressure). Where conducting and abrasive dusts are present, even lower pressure may be necessary and suction is to be preferred, as damage can easily be caused by blowing the dust and metal chips into the insulation.

On large machines, insulation resistance readings should be taken in the manner indicated earlier in this article. As long as the readings are consistent the condition of the insulation would ordinarily be considered good.

Cleaning

About once a year, or oftener if conditions warrant, motors should be overhauled. Smaller motors, the windings of which are not particularly accessible should be taken apart. First, the heavy dirt and grease should be removed with a heavy, stiff brush, wooden or fiber scrapers and cloths. Rifle-cleaning bristle brushes can be used in the air ducts. Dry dust and dirt may be blown off, using dry compressed air of 25 to 30 lb. pressure, taking care to blow the dirt out from the winding. As stated before, if the dirt and dust is metallic, conducting, or abrasive, air pressure may drive the material into the insulation and damage it. Hence, for such conditions, pressure is not so satisfactory as a suction system. If compressed air at low pressure is used, care must be taken to direct it properly so that the dust will not cause damage and will not be pocketed in the various corners.

Grease, oil and sticky dirt are easily removed by applying cleaning liquids like carbon tetrachloride (pyrene, carbona), gasoline, or naphtha. All of these liquids evaporate quickly and, if not applied too generously, will not soak or injure the insulation. Carbon tetrachloride is best and is recommended because it is non-inflammable.

In case one of the liquids must be used, it should be applied out of doors or in a well-ventilated room. It must be remembered that gasoline or naphtha vapor is heavier than air and will flow into pits, basements, etc., and may remain there for hours or even days. The casual smoker, a spark from a hammer or chisel, or even from a shoe nail may cause a serious explosion. Therefore, proper ventilation of the room is essential and may require specially piped ventilating fans. In using carbon tetrachloride the explosion hazard is eliminated, but some ventilation is required to remove the vapor, which might affect the safety and comfort of the workmen.

There are several good methods of applying the cleansing liquid. A cloth, saturated in the liquid, may be used to wipe the coils. A paint brush, dipped in carbon tetrachloride, is handy to get into corners and crevices, and between small coils. Care should be taken not to soak the insulation as would be the case if coils or

small machines were dipped into the liquid. Probably the best method of applying the liquid is to spray it on. A spray gun, paint spraying appliance, or an ordinary blow torch are often used with good results, although the latter device is apt to give a heavier spray than desirable.

An atomizer will give excellent results, using a pressure of about 80 lb. if the insulation is in good condition, or 40 to 50 lb. if the insulation is old. The atomizer should be held not more than 5 or 6 in. away from the coils.

While the insulation will dry quickly at ordinary room temperature after such cleaning methods, it is highly desirable to heat it to drive off all moisture before applying varnish.

If the motor can be spared from service long enough, the insulation should be dried out by heating to from 90 to 100 deg. C. While warm, a high-grade insulating varnish should be applied. For severe acid, alkali, or moisture conditions, a black plastic baking varnish is best, while for conditions where oil or dusts are present, a clear or yellow varnish should be used.

The varnish may be sprayed or brushed on. For small stators or rotors, it is best to dip the windings into the varnish, cleaning off the adjacent metal parts afterwards by using a solvent of the varnish. After applying the varnish, the best results are obtained by baking for 6 to 7 hr. at about 100 deg. C. Experience with particular conditions of operation, or the condition of the insulation, may indicate the desirability of applying a second coat of the same varnish, followed again by 6 to 7 hr. baking at 100 deg. C.

If the machine must be put back in service quickly, or if facilities are not available for baking, fairly good results will be obtained by applying one of the quick-drying black or clear varnishes which dry in a few hours at ordinary room temperatures.

Insulation resistance readings should be taken, as explained previously, to determine whether the winding is in satisfactory condition for applying a high-potential test. After this test, it is good practice to run the motor without load for a short time, to make certain that everything has been connected, assembled, and adjusted properly.

Comments on the Technique of Electric Welding

PIPE FOR ARC WELDING SHOULD BE SCARFED ONLY 30 DEG., AND CARE USED IN SELECTION OF ELECTRODES AND IN BEGINNING AND ENDING OF WELD. BY E. R. BENEDICT*

ONE IMPORTANT difference in the electric arc welding of pipe from that of oxy-acetylene welding is in the scarfing of the pipe. The pipe for arc welding should have a bevel of only 30 deg. from the vertical for real economy, instead of 45 deg. as generally used and as illustrated in the sketch, Nearly 50 per cent more metal must be deposited by the operator if the usual 45-deg. scarf is used, as for oxy-acetylene welding.

This surplus metal added to the 45-deg. scarfed pipe adds nothing to the strength of the weld and in all probability detracts from it, as a surplus of heat must be added to the weld to deposit the extra metal.

The 30-deg. bevel leaves sufficient room for the operator to penetrate to the bottom of the weld so that the inner edges of the pipe are thoroughly bonded.

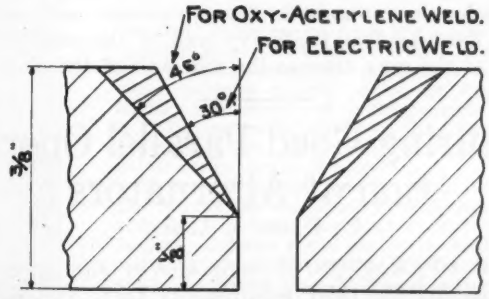
At the same time, the more acute scarfing does not require such a wide reinforcing bead to be built up, All pipe welds should be built up to a thickness equal to at least ten per cent of the thickness of the pipe wall.

Operators obtained for electric arc welding of pressure piping must be very high type of mechanics to insure the success of this operation. It is only after considerable experience on pipe work that the operator becomes proficient. He must also be a competent oxy-acetylene cutting-torch operator with sufficient geometric sense to cut and fit angles for which templates are not supplied.

The most satisfactory type of arc-welding unit for field work is that having a welding generator mounted on a tractor. The welding generator supplied with this unit is a 200-amp. machine, with an open circuit voltage regulation of 30 to 70 v. and a range of amperage from 50 to 200. It has a separate exciter which may also be used for lighting a 40-w. 110-v. lamp, which is convenient for the operator when working at night or in dark places.

CAREFUL SELECTION OF ELECTRODES IS NECESSARY

Careful selection of metallic electrodes is necessary for good welding. After long experimentation, the No.



PROPER ANGLES TO BE USED IN SCARFING PIPE FOR WELDING

3R pink-coated electrode was selected for welding on steel or wrought iron pipe. This is a mild steel rod which gives a filler metal which is exceedingly ductile and fuses readily with the pipe to give a satisfactory weld. These rods were selected because of their uniform high quality. The pink coating, which is a flux, removes the occluded nitrogen and forms a slag coating over the weld to prevent oxidation. This slag coating is readily removable from the weld with a wire brush.

The mechanics of making a weld are not very complicated, although a few important precautions must be exercised. For a straight run of pipe of several lengths which can be revolved as it is welded, the pipe is set in cradle rollers. Then, by means of wedges under these cradles, the pipes are raised or lowered or moved until they are in alinement, this alinement being determined by means of a long straightedge placed on the sides and

*American District Steam Co. Statement included in annual report of Distribution Committee of N. D. H. A. at West Baden, Ind., June, 1927.

top of the pipe. The scarfed ends are kept about 1/8 in. apart to assist the operator in getting his weld through on the inside of the pipe.

With an open-circuit voltage of between 40 and 50 v. and using a 1/8-in. diameter electrode, the operator runs a sealing bead of filler metal completely around the two pipes. This bead extends from the inside of the pipe wall to a little more than half way out of the pipe-wall thickness. A second bead is then run over this first bead using a 5/32-in. diameter rod. This bead completely fills the scarf and is built up to a reinforcing thickness of 10 per cent of the pipe wall thickness.

Beginning and Ending of Weld

At the point where the weld begins and ends, particular care must be exercised by the operator or a crater will be left which is porous and not steam or liquid tight. To eliminate this porosity, it is best to peen this point with a machine hammer.

At points where it is not practical to revolve the pipe and where the operator can get under and around the pipe, it is easy to do "overhead" arc welding. Not as much room is required as with acetylene welding and there is not the excess heat given off to cause discomfort to the operator and cause him to shirk his work.

Where there is not sufficient room for the operator to get around a weld which is stationary, a hole may be cut in the top or side of the pipe to allow the operator to get his arm or even just the electrode inside and the weld may be made, the hole being finally covered with a patch.

In welding in cast-steel fittings, such as valves and expansion joints, the electric arc process has been found to be much more satisfactory than oxy-acetylene, because few operators with the gas process can control their flame so that the heavy wall of the cast fitting flows at the same time as the thin wall of the pipe.

Securing Good Parallel Operation of Alternators

By Harry J. Achee

FOR OPERATION of engine-driven alternators in parallel the chief requirements are: (1) Equal average speed of engines; this means rather heavy flywheels and good valve setting. (2) Fairly sluggish governors which will not respond too quickly to slight changes of load. (3) Some means to choke out any "pumping," such as solid pole shoes, or copper dampers if the poles are laminated. (4) Speed drop from no load to full load the same in each engine, otherwise they will not divide the load properly. Requirements Nos. 1 and 3 must be taken care of by the manufacturer, but Nos. 2 and 4 can be adjusted after installation.

If the engine regulation is too "close" that is, if speed does not drop appreciably as load comes on, good parallel operation is impossible. Suppose, for example that two engines driving generators in parallel ran at exactly the same speed at full load as at no load. There would then be no tendency for either to "get out from under" when load came on and thus give part of the load to the other machine; consequently the load might go to either one and not be divided between them. When paralleling a slow speed unit with a high speed unit, it is almost always found that the high speed machine tends to take the load away from the low speed unit, particularly on sudden load increases. This is because the high speed machine is quicker to govern. If this is objectionable, it can be overcome by placing dashpots on the governor of the high speed machine to make it more sluggish.

Trouble from pumping is likely to occur if either engine shows unequal indicator cards for the two ends of the cylinder. Such poor adjustment causes uneven speed of rotation and can be remedied by proper setting of the valve gear.

The only way to make each machine to take and hold its share of the load is to make the engine hold up speed equally. Little or nothing can be accomplished by juggling the field rheostats. Increasing the field strength of a direct-current machine makes it take load, but this is not true of an alternator. Increasing the field strength makes the alternator generate more voltage, but the extra voltage is used to circulating wattless current through the stator windings of both machines. Hence the ammeter readings will change but the wattmeters will not. To reduce the wattless current between the two machines to a minimum their field should be so adjusted that the two machines give the same voltage at no load. A few trials will show just where the rheostats should be set for regular service conditions.

If cross-current or pumping is troublesome on two machines having separate exciters, it is well to parallel the exciters or excite both alternators from one exciter. Connecting together two rotors in this way causes them to act as dampers on each other and helps considerably to kill any "swinging" of the load.

Distribution of Ash-Forming Constituents in Coal

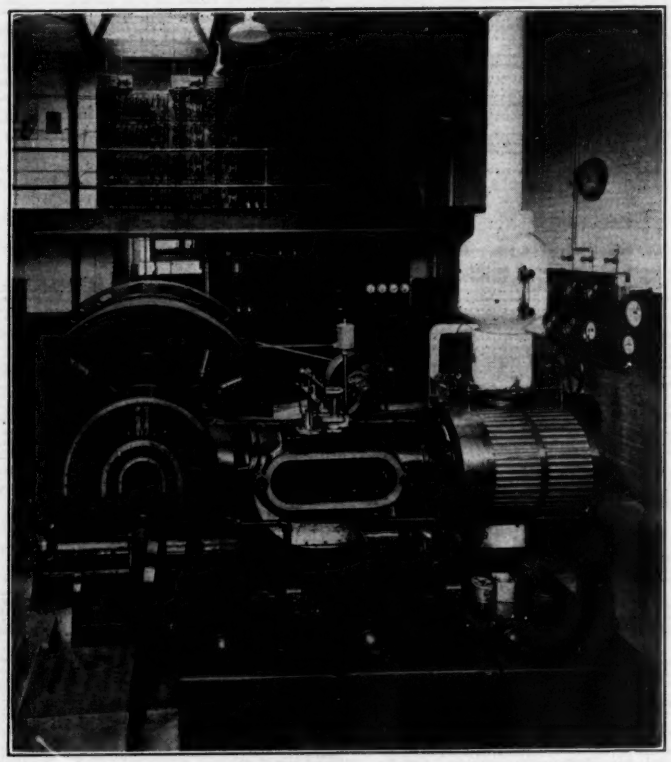
Ash-forming constituents of coal may be roughly classified as inherent impurities and extraneous impurities, state W. A. Selvig, chief chemist, Bureau of Mines, and W. L. Gardner, research fellow, Carnegie Institute of Technology, in a recently issued bulletin. The former are mixed more or less intimately with the coal substances, and are derived either from the original coal-forming material or from external sources such as sedimentation and precipitation while the vegetal coal-forming plant remains accumulated. The latter are present in the coal bed as partings, bands, or nodules of pyrite, slate, shale, calcite, bone, etc. These are formed either during the laying down of the coal bed or subsequently. Fragments of roof and floor which became mechanically mixed with the coal in the process of mining also contribute to the extraneous impurities.

By carefully burning a lump of coal in a muffle furnace, an ash skeleton may be obtained which, if examined, will usually show that the mineral matter is not uniformly distributed through the coal mass. Investigation of a number of British coals has shown that this matter is not uniformly distributed throughout the coal mass; also that coal may break up on handling or crushing into fragments which differ considerably in percentage and composition of ash.

Palmer House Laundry, Separate from Hotel, Includes Well-Equipped Small Power Plant

TO LAUNDER THE LINENS of the Palmer House, Chicago, Ill., a complete laundry plant has recently been erected by the Palmer Estate at 34th Place and Rhodes Ave., Chicago, in which are incorporated the most modern laundry equipment and methods. Steam and hot water demands of this laundry naturally led to the installation of a power plant, of which the principal equipment is shown herewith.

The laundry itself is designed to handle 20 t. of flat work each 9-hr. day, in addition to about $700 worth of starch work. It is managed by E. B. McCarthy with A. M. Bartlett as chief engineer.



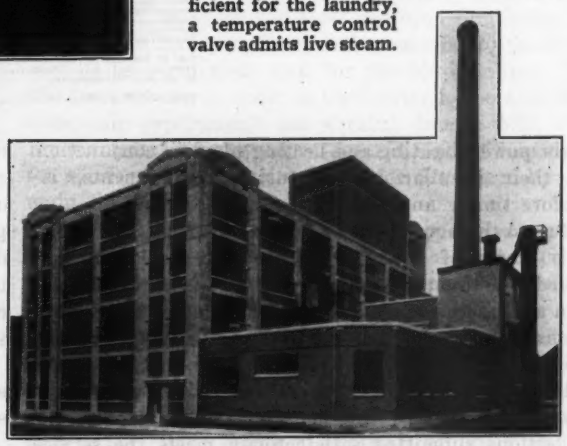
Steam is generated by a 400-hp. water-tube boiler with a setting designed for operation at 200 per cent of rating. Coal is burned on a chain grate stoker driven by a steam engine. Coal is elevated to a 100-t. concrete bunker, with a return spout to re-circulate coal in case of fire or surplus supply. The ash bunker is at the end of the coal bunker, ash being conveyed by a steam jet ash conveyor. Automatic combustion control equipment, duplex reciprocating boiler feed pumps, an open feed water heater and a vaccum pump for the heating system are installed. In the engine room is a single-cylinder, slide-valve engine, driving a 300-kv.a., 0.8-p.f., 3-phase, 60-cycle generator which supplies electric power for the laundry machinery and lighting circuit. A 14-kw. exciter is belt driven from this generator shaft. A throw-over to the public utility service is provided.

The engine supplies exhaust steam for the heating system, laundry machinery and the feed water and laundry water heaters. Exhaust steam goes to the feed water heater and the excess is led to a steam jet heater in a 20,000-gal. water storage tank. If this exhaust is not sufficient for the laundry, a temperature control valve admits live steam.

All water used in laundry and power plant is run through a 22,000-g.p.h. water softener. Cold water is stored in a 30,000-gal. roof tank.

In the engine room are installed the main generator control board and, on the gallery above it, the automatic control board for the laundry machinery. By placing this automatic board in the engine room, the circuits needing heavy copper could be made very short, the circuits to individual machines being run through pipe conduit.

All instruments and accessories necessary for convenience and for obtaining complete records of operation have been provided and the power plant was designed with space for additional units in case of expansion. The laundry and power plant were designed and built by The Austin Co.



Comparison of Power Plant Costs

Study Made to Determine Best Equipment to Give Lowest Power Cost in a Particular Industrial Power Plant

EQUIPMENT for industrial power plants is frequently selected without thorough analysis of the relative values of all different possible arrangements. The following careful analysis, which is taken from a report by W. J. Neely, consulting engineer, Chicago, made for a local machinery manufacturing concern in order to determine what changes should be made in their present power, lighting and heating plant in conjunction with their peculiar manufacturing requirements, is therefore timely and valuable.

Due to the age and poor condition of the old plant, the purchase of entirely new equipment was recommended. Estimates were therefore made of the installation and operation costs of eight different service propositions based upon best modern engineering practice, first-class equipment and conservative ratings, with safety and convenience of operation, reliability of service and economy as prime considerations. Each of the propositions submitted satisfactorily meets the service demanded by the industrial plant but the propositions differ widely in first cost and also considerably in yearly service cost as shown in the Summary of Costs tabulated herewith.

Description of Proposed Power Plants

Proposition No. 1 provides for the installation of a modern and economical private plant, high pressure water-tube boilers, superheaters, poppet valve or uniflow engines, a.c. generators, poppet valve engine driven air compressor for the large unit and motor-driven compressor for the small unit, three phase, 440-v. electrical distribution system, 110-220-v. three-wire lighting systems, a.c. motors and control equipment, and motor-generator sets for generating d.c. current for cranes and special service.

Proposition No. 2 is the same as No. 1, except that superheaters are omitted and four-valve engines are substituted for driving the power generating units.

Proposition No. 3 is the same as No. 2 except that d.c. generators are substituted for a.c. generators, con-

PROPOSITION NO. 1

Private plant with Poppet Valve or Uniflow Engines

2 - 400 hp. Water Tube Boilers (normal rating)	$16,000.00
2 - 100 Deg. Superheaters	2,400.00
Boiler Brickwork	10,000.00
2 - Stokers	12,000.00
2 - Forced Draft Fans	2,200.00
Draft & Furnace Control Equipment	2,000.00
Feed Water Meter and Boiler Room Instruments	1,500.00
Breechings	2,000.00
Feed Water Heater (1,000 hp.)	1,200.00
2 - Boiler Feed Pumps	1,700.00
2 - Vacuum Pumps	1,000.00
Coal and Ash Handling Equipment	7,500.00
1 560 kw. Poppet-Valve Engine, a.c. Generator and Exciter	25,750.00
1 - 300 kw. Poppet-Valve Engine, a.c. Generator and Exciter	18,700.00
1 - 75 kw. Four-Valve Engine and d.c. Generator	8,300.00
1 - 100 kw. Motor Generator set	3,000.00
Switchboard and Wiring	7,500.00
Piping for Boilers, Engines and Other Equipment	22,000.00
Pipe Insulation	3,500.00
1 - 1,000 ft., 110-lb., Uniflow Engine Driven Air Compressor and Receiver	7,850.00
1 - 500 ft., 110-lb., Motor Driven Air Compressor	4,200.00
Foundations and Erection	16,500.00
Cost of Power Plant	178,800.00
Cost of Electrical Distribution System	35,625.00
Cost of a.c. Motors and Controllers	19,378.80
Cost of Installation	231,803.80
Fees	13,908.23
10 per cent Contingencies	24,371.80
TOTAL APPROPRIATION	$270,285.23

PROPOSITION NO. 2

Private Plant with Four-Valve Engines and a.c. Generators

2 - 400 hp. Water Tube Boilers (normal rating)	$16,000.00
Boiler Brickwork	10,000.00
2 - Stokers	12,000.00
2 - Forced Draft Fans	2,200.00
Draft and Furnace Control Equipment	2,000.00
Breechings	2,000.00
2 - Boiler Feed Pumps	1,700.00
Feed Water Heater (1,000 hp.)	1,200.00
2 - Vacuum Pumps	1,000.00
Feed Water Meter and Boiler Room Instruments	1,500.00
Coal and Ash Handling Equipment	7,500.00
1 - 500 kw. four-valve Engine, a.c. generator and Exciter	22,200.00
1 - 300 kw. four-valve Engine, a.c. generator and Exciter	17,100.00
1 - 75 kw. four-valve Engine and d.c. generator	8,300.00
1 - 100 kw. Motor Generator Set	3,000.00
Switchboard and Wiring	7,500.00
Piping for Boilers, Engines and other equipment	19,000.00
Pipe Insulation	2,500.00
1 - 1,000 ft., 110 lb. Uniflow Engine Driven Air Compressor and Receiver	7,850.00
1 - 500 ft., 110 lb. Motor Driven Air Compressor	4,200.00
Foundations and Erection	16,500.00
Cost of Power Plant	167,250.00
Cost of Electrical Distribution System	33,625.00
Cost of a.c. Motors and Controllers	19,378.80
Cost of Installation	220,253.80
Fees	13,215.23
10 per cent contingencies	23,346.90
TOTAL APPROPRIATION	$256,815.93

PROPOSITION NO. 3

Private Plant with Four-Valve Engines and d.c. generators

2 - 400 hp. Water Tube Boilers (normal rating)	$16,000.00
Boiler Brickwork	10,000.00
2 - Stokers	12,000.00
2 - Forced Draft Fans	2,200.00
Draft and Furnace Control Equipment	2,000.00
Breechings	2,000.00
Feed Water Heater (1,000 hp.)	1,200.00
2 - Boiler Feed Pumps	1,700.00
2 - Vacuum Pumps	1,000.00
Feed Water Meter and Boiler Room Instruments	1,500.00
Coal and Ash Handling Equipment	7,500.00
1 - 500 kw. Four Valve Engine and d.c. Generator	26,700.00
1 - 300 kw. Four Valve Engine and d.c. Generator	20,000.00
1 - 75 kw. Four Valve Engine and d.c. Generator	8,300.00
Switchboard and Wiring	7,500.00
Piping for Boilers, Engines and Other Equipment	19,000.00
Pipe Insulation	2,500.00
1 - 1,000 ft., 110-lb., Uniflow Engine Driven Air Compressor and Receiver	7,850.00
1 - 500 ft., 110-lb., Motor Driven Air Compressor	4,200.00
Foundations and Erection	16,500.00
Cost of Power Plant	171,750.00
Rehabilitation of Electrical Distribution System	16,600.00
Cost of Installation	188,350.00
Fees	11,301.00
10 per cent contingencies	19,965.10
TOTAL APPROPRIATION	$219,616.10

PROPOSITION NO. 4

Steam Turbine Plant - a.c. Generators

2 - 400 hp. Boilers (Normal Rating)	$16,000.00
100 Deg. Superheaters	2,400.00
Boiler Brickwork	10,000.00
2 - Stokers	12,000.00
2 - Forced Draft Fans	2,200.00
Draft and Furnace Control	2,000.00
Feed Water Meter and Boiler Room Instruments	1,500.00
Breechings	2,000.00
1 - Feed Water Heater (1,000 hp.)	1,200.00
2 - Boiler Feed Pumps	1,700.00
2 - Vacuum Pumps	1,000.00
Coal and Ash handling Equipment	7,500.00
1 - 500 kw. turbine including Exciter	12,000.00
1 - 300 kw. turbine including Exciter	8,500.00
1 - 75 kw.Four Valve Engine and d.c. Generator	8,300.00
1 - 100 kw. Motor Generator Set	3,000.00
Switchboard and Wiring	7,500.00
Piping for Heller Turbine and Other Equipment	23,000.00
Piping Insulation	3,500.00
1 - 1000 ft., 110-lb., Uniflow Engine Driven air Compressor and Receiver	7,850.00
1 - 500 ft., 110-lb., Motor Driven Air Compressor	4,200.00
Foundations and Erection	7,500.00
Cost of Power Plant	148,250.00
Cost of Electrical Distribution System	33,625.00
Cost of a.c. Motors and Controllers	19,378.80
Cost of Installation	201,253.80
Fees	12,075.23
10 per cent Contingencies	21,332.90
TOTAL APPROPRIATION	234,661.93

PROPOSITION NO. 5

Private Plant with Oil Engines and a.c. Generators

1 - 500 kw. Oil Engine, a.c. Generator and Exciter	$61,200.00
1 - 300 kw. Oil Engine, a.c. Generator and Exciter	37,950.00
1 - 75 kw. Oil Engine and d.c. Generator	10,600.00
1 - 100 kw. Motor Generator Set	3,000.00
Piping and Tanks	8,000.00
1 - 1000 ft., Oil Engine Driven Air Compressor and Receiver	18,000.00
1 - 500 ft., Motor Driven Air Compressor	4,200.00
1 - Motor Driven Fire Pump	4,000.00
Switchboard and Wiring	7,500.00
2 - Heating Boilers	7,076.00
Breeching	800.00
2 - Motor Driven Vacuum Pumps	2,000.00
Piping	8,500.00
Insulation	1,500.00
Foundations and Erection	14,000.00
Cost of Power Plant	189,826.00
Cost of Electrical Distribution System	33,625.00
Cost of a.c. Motors and Controllers	19,378.80
Total Cost of Installation	242,829.80
Fees	14,833.79
10 per cent Contingencies	25,676.36
TOTAL APPROPRIATION	$283,439.95

PROPOSITION NO. 6

Public Service Current, Motor Generators, Present Motors and Heating Plant

Transformer Vault	4,000.00
Switchboard and Wiring	7,968.00
500 kw. Synchronous Motor Generating Set	9,880.00
300 kw. Synchronous Motor Generating Set	8,688.00
1000 C.F.M. Synchronous Motor Driven Compressor	8,400.00
500 C.F.M. Synchronous Motor Driven Compressor	6,710.00
Electric Motor Driven Fire Pump	4,000.00
Rehabilitation of Electrical Distribution System	16,600.00
Heating Boilers	7,076.00
Breeching	800.00
Vacuum Pumps (electric)	2,000.00
Piping	8,500.00
Covering	1,500.00
Foundations and Erection	2,000.00
Cost of Installation	89,056.00
Fees	5,343.36
Contingencies, 10 per cent	9,429.93
TOTAL APPROPRIATION	103,829.29

PROPOSITION NO. 7

Public Service Current, Rotary Converters, Present Motors and Heating Plant

Transformer vault	$ 4,000.00
Switchboard and Wiring	7,968.00
800 kw. Rotary Converter	10,488.00
300 kw. Rotary Converter	7,340.00
1000 C.F.M. Synchronous Motor Driven Compressor	8,400.00
500 C.F.M. Synchronous Motor Driven Compressor	6,710.00
Electric Motor Driven Fire Pump	4,000.00
Rehabilitation of Electrical Distribution System	16,600.00
Heating Boilers	7,076.00
Breeching	800.00
Vacuum Pumps	2,000.00
Piping	8,500.00
Covering	1,500.00
Foundations and Erection	2,000.00
Cost of Installation	$ 90,378.00
Fees	5,420.28
10 per cent Contingencies	9,579.30
TOTAL APPROPRIATION	$105,372.58

PROPOSITION NO. 8

Public Service Current, a.c. Motors and Heating Plant

Transformer vault	$ 6,000.00
Switchboard and Wiring	9,468.00
100 kw. Synchronous Motor Generating Set	3,303.00
75 kw. Synchronous Motor Generating Set	2,918.00
1000 C.F.M. Synchronous Motor Driven Compressor	8,400.00
500 C.F.M. Synchronous Motor Driven Compressor	6,710.00
Electric Motor Driven Fire Pump	4,000.00
Electrical Distribution System	33,625.00
A.C. Motors and Control Equipment	19,378.80
Heating Boilers	7,076.00
Breeching	800.00
Vacuum Pumps	2,000.00
Piping	8,500.00
Covering	1,500.00
Foundations and Erection	1,600100
Cost of Installation	$116,272.80
Fees	6,976.37
10 per cent Contingencies	12,924.92
TOTAL APPROPRIATION	$136,574.09

TABLE I. ESTIMATED COST OF EQUIPMENT FOR EIGHT DIFFERENT PROPOSED ARRANGEMENTS

tinuing the old motor equipment in service. It includes rehabilitation of the electrical distribution system.

Proposition No. 4 is the same as No. 1 except that steam turbines are substituted for poppet-valve engines for driving the power generators.

Proposition No. 5 provides for oil engine driven a.c. generators, oil engine drive for the large air compressor, motor drive for the small unit, the same electrical distribution system, motor equipment, lighting system, and motor-generator sets provided as in Plan No. 1 and low pressure boilers for the heating system.

Proposition No. 6 provides for public service current, motor-generator sets to serve the power requirements, synchronous motor-driven air compressors, motor-driven fire, vacuum and oil pumps, 110-220-v. three-wire a.c. lighting system, rehabilitation of the electrical distribution system and low pressure heating boilers for the heating system.

Proposition No. 7 is the same as No. 6 except that rotary converters are substituted for motor-generator sets.

Proposition No. 8 provides for public service current, with the same electrical distribution system, lighting system, motors and motor-generator sets as provided in Plan No. 1; synchronous motor-driven air compressors, motor-driven fire, vacuum and oil pumps, and low pressure boilers for the heating system.

TABLE II. SUMMARY OF EQUIPMENT AND SERVICE COSTS FOR THE VARIOUS PROPOSED ARRANGEMENTS

Proposition	1	2	3	4	5	6	7	8
Total appropriation	270283.23	256815.93	219616.10	234661.93	282439.95	103839.29	105372.58	135574.09
Annual fixed charges	40542.48	38522.39	32942.42	35199.29	42365.99	15575.89	15805.88	20336.11
Annual operating costs	28440.00	31272.00	31272.00	34512.00	*21245.00	42772.56	42079.08	41233.92
Total annual service charge	68982.48	69794.37	64214.42	69711.29	63710.99	58348.45	57884.96	61570.03
*plus additional maintenance cost of 2 per cent of engine cost								

Basis of Calculations

Fixed Charges: The fixed charges are in all cases taken as 15 per cent per annum on the total investment, segregated as follows:

Interest	5 per cent
Depreciation or Obsolescence	5 per cent
Maintenance and miscellaneous supplies	4 per cent
Insurance and Taxes	1 per cent

While it is true that depreciation and maintenance charges vary considerably on different items, practice has demonstrated that 15 per cent of the total investment is a fair average carrying charge.

Labor Charges: Power Plant

1 Chief Engineer	$ 300.00	per mo.
3 Watch Engineers at $180 each	540.00	
3 Fireman Engineers at $150 each	450.00	
2 Maintenance men at $135 each	270.00	
Total	$1560.00	per mo.

Oil Engine Plant

1 Chief Engineer	$ 300.00	per mo.
3 Watch Engineers at $200 each	600.00	
2 Maintenance men at $135 each	270.00	
½ Night Watchman's time	81.00	
2 Firemen 7 mo. at $162	189.00	
Total	$1440.00	per mo.

Public Service Current and Heating Plant

1 Chief Electrican	$ 300.00	per mo.
3 Station Operators at $150 each	450.00	
2 Maintenance men at $135 each	270.00	
½ Night Watchman's time	81.00	
Total	$1101.00	per mo.

Fuel Charges: Power Plant

The fuel charge for the private plant is based on Illinois or Indiana 1¼-in. screenings delivered to the plant at $3.50 per t. In estimating the steam requirements, the steam rate guarantees of the engine builders have been taken, plus 25 per cent for unavoidable losses, i.e., starting and banking fires, light load operation and auxiliaries. The fuel charge for the heating plant is based on coal at $4.00 per t. delivered. Based on 400 lb. of steam per sq. ft. of radiation per year, the fuel cost for heating would be $8000 a year or $666.66 per month.

Electrical Requirements: The average monthly current consumption is estimated at 90,000 kw-hr. with a maximum demand of 400 kw. This amount includes current required to operate the air compressors. In propositions where a steam-driven compressor is used the power is computed as electrical energy to simplify the comparisons.

Yearly service charges for higher as well as lower electrical loads were checked and little variation in comparative costs were found.

Discussion

Generating units: In selecting units of 500, 300 and 75 kw. capacity, consideration was given to flexibility, economy and continuous operation. According to plant records the maximum demand for current is 400 kw. This peak occurs only when the foundry cupola is in operation. Allowing for a 50 per cent production increase, the extra power demand would be 20 to 30 per cent or an economical load for the 500-kw. unit. The 300-kw. unit can be used on the lighter loads, and when some shop departments are working double shift. The 100-kw. motor generating set is for d.c. crane and elevator service. The 75-kw. unit is for d.c. stand-by and night load.

Power Plant Boilers: Two 400-hp. boilers which represent the maximum capacity of the present stack were selected. This provides ample capacity to operate the entire plant on one boiler.

Air Compressors: In selecting the air compressors, it was decided that the 1000 cu. ft. unit would supply the normal plant requirements efficiently with the 500 cu. ft. unit for light load operations and to serve as reserve for either increased demands or breakdown of the large machine.

Private Plant: In reviewing the cost summary, it is interesting to note the small difference between the annual service cost of the private plant and the public service plant. In reviewing the possibilities of all the private plant plans, some striking features are clearly brought out by the tabulations.

1. Owing to the present plant being entirely obsolete and rehabilitation with a reasonable expenditure out of the question, an entire new plant with the exception of the stack must be provided.

2. As no demand is made for steam for a large heating load or process work, the exhaust steam is wasted five months of the year.

3. An adequate supply of water for condensing purposes is not available; consequently the plant cannot be economically operated during the non-heating period. It is interesting to note that with the low operating charge of the private plant, if either the boilers or generating units could be used with a small expenditure for rehabilitation to restore them to their original efficiency, the private plant would be decidedly the best proposition. In this plant with no refuse for fuel, a moderate heating load and no demands for process steam, a substantial saving can be made by buying power instead of operating a private plant; especially when electric rates are favorable.

Public Service Plant: In comparing propositions No. 6 and No. 7, the question is motor generators versus rotary converters.

Motor Generators: (Advantages) Have greater power factor correction, ample voltage regulation, lower maintenance, lower first cost and are more easily understood by attendants. (Disadvantages) Lower efficiency and smaller overload capacity.

Rotary Converters: (Advantages) Higher efficiency, and larger overload capacities at unity power factor. (Disadvantages) Limited voltage adjustment, no power factor correction, higher maintenance, more difficult to operate.

Propositions No. 6 and 7: In considering Propositions No. 6 and 7 we would recommend Proposition No. 6, which provides motor-generator sets, the advantages of which justify the small increased service cost.

Proposition No. 8: In comparing Proposition No. 8 with either Proposition No. 6 or No. 7 the question is a.c. versus d.c. equipment.

A.C. Motors: (Advantages) Lower first cost, lower maintenance, higher overload capacity. (Disadvantages) None.

D.C. Motors: (Advantages) None. (Disadvantages) Higher first cost, higher maintenance, small overload capacities and obsolete for the majority of manufacturing plants.

On first consideration Proposition No. 8 seems to be handicapped by a high first cost with resultant higher service cost. The operating costs of Proposition No. 8 are lower than operating costs of either Proposition No. 6 or No. 7. The first cost of Proposition No. 8 provides a new electrical distribution system, with new a.c. motors and control equipment, which we believe justifies the expenditure. The present d.c. motors and control equipment, which must be continued in service if Proposition No. 6 or No. 7 is adopted, have depreciated to a point where maintenance charges are high and extensive repairs or replacements will be necessary to insure uninterrupted service. In addition to the lower service cost, the public service plant has an advantage of releasing space which is valuable for manufacturing purposes.

Recommendations: It is evident from the findings as set forth that the public service propositions have the following advantages over a private plant: Lower first cost, lower yearly service charges and minimum space requirements.

Of the three public service propositions presented, Proposition No. 8 was therefore recommended.

The changes, following this plan, were made without interfering with the operation of the plant and the actual cost came within the original estimate without the need of the 10 per cent contingency fund.

Simple Method of Measuring a River

MANY LETTERS are received by the Geological Survey, Department of the Interior, inquiring for some easy method of determining the approximate flow of streams or small rivers, where regular river-measuring instruments are not available. The method described below is considered useful under such conditions.

To ascertain the velocity of the stream choose a place where the channel is straight for 100 or if possible 200 ft. and where it has a nearly constant width and depth and smooth current. Lay off on the bank the center 50 or 100 ft. of the straight reach of the stream, marking each end. Then allow small chips to float down the stream, noting the time required for these to traverse the distance laid off on the bank. The surface velocity in feet per second is obtained by dividing the distance in feet passed over by the chips by the time in seconds it takes them to travel this distance. The average result of several such tests, made at different positions from bank to bank, will give the mean or average surface velocity of the stream. This result multiplied by 0.8 gives very nearly the average velocity of the entire flow of the stream. This is the first step.

To obtain the area of the cross section of the stream, stretch a tape from shore to shore and take the depth of the stream at short intervals—2 or 5 ft. The average of these depths may be assumed as the average depth of the stream at this point. This average in feet multiplied by the total width in feet will give the area of the cross section of the stream in square feet. The volume of the discharge of the stream is now found by multiplying this cross-section figure by the average velocity, feet per second, as obtained by the chip measurements, the result being the discharge in second-feet, or, in other words, the number of cubic feet of water flowing past the point of measurement each second.

SALES OF MECHANICAL STOKERS for the month of June, 1927, as reported by the Department of Commerce show a total of 153 stokers sold, installed under boilers of 54,804 hp. capacity. Of this number 49 stokers were installed under fire-tube boilers of 7646 hp. and 104 stokers under water tube boilers of 47,158 hp. These figures show a decided increase over those for April and May of this year. Total number of stokers installed in May was 97 under 43,601 hp. of boilers. Of this number 16 were under fire-tube boilers.

New Ice Plant Marks Refrigeration Progress

PHILADELPHIA PLANT HAS HIGH SPEED COMPRESSORS, TUBULAR TYPE CONDENSERS, SYNCHRONOUS MOTORS AND OTHER MODERN REFRIGERATING EQUIPMENT

THAT THERE HAS been great development in the field of mechanical refrigeration is reflected in the appearance of the new ice plant of the Premier Ice Co., located at Stenton Ave. and Walnut Lane in Germantown, near Philadelphia. This plant incorporates all the desirable features, high quality ice, low first cost, low operating cost and a plant unobjectionable in appearance to a residential section, in a neat one story building. The plant is rated at 75 t. and was designed by Van Rensselaer H. Green, refrigerating engineer, of New York City. It is electrically operated, all current being supplied by the Philadelphia Electric Co. at 2300 v., 2 phase, 60 cycle.

The building, which occupies an area 114 ft. long by 100 ft. wide, is a one-story structure constructed to conform with the architectural design of the surrounding district. This plant, as has been noted, is located in Germantown in which a particular type of stone masonry has come to be recognized throughout the country. The plant of the Premier Ice Co. is built to conform to this type of architecture, being built entirely of stone.

Besides the compressor room and the ice making room, there is an ice storage room 38 ft. wide by 79 ft. long. The location of the office is such that a complete view of the compressor room and the ice delivery platform can be had from this office.

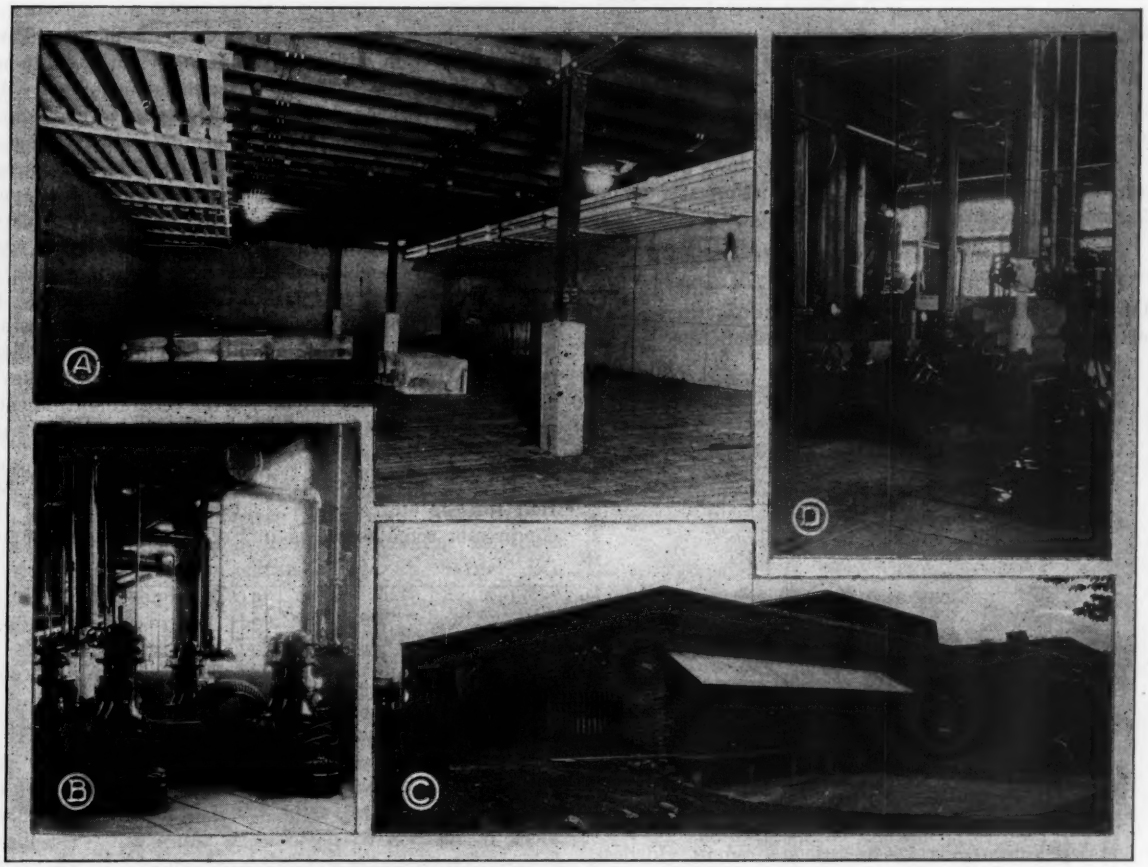


FIG. 1. VIEWS IN THE NEW PLANT OF THE PREMIER ICE CO.

A.—General view in the ice storage room. This room is 38 ft. long 79 ft. wide and is insulated with 4 in. of corkboard on floor and walls and 5 in. on the roof. B.—Four vertical ammonia compressors are driven by 2 synchronous motors. C.—An outside view of the Premier Ice Plant. D.—Another corner of the compressor room showing one of the compressors, the two water circulating pumps and stairway to ice tank.

A transformer room is provided for stepping the voltage down to that required by the motors. The entrance to this room is only from the outside, so fire doors were eliminated between the transformer and compressor rooms. The switchboard is placed just outside of the transformer room as shown in Fig. 3.

Insulation for the ice storage room consists of 4 in. of corkboard on the floor and walls, and 5 in. of cork on the roof. On the walls, the cork is set up in asphalt and a cement finish is used over the interior surface. On the roof corkboard is placed over the sheathing so that

FIG. 2. A VIEW OF THE ICE MAKING TANK LOOKING TOWARD THE COMPRESSOR ROOM

the ceiling beams are exposed in the room below. The roofing is applied directly on top of the corkboard.

The building is fitted with large windows all around providing excellent day light illumination throughout all parts of the plant.

One Motor Drives Two Compressors

Refrigerating effect is supplied by 4 separate ammonia compressors, all of the York Manufacturing Co.'s vertical, enclosed type. The compressors are paired, each pair being driven by a synchronous motor. They are 7½ by 7½-in. units, driven at 360 r.p.m. by 120-hp. Electric Machinery Co. 2300-v. synchronous motors. An interesting feature of these compressors is their small size. It will be noted that they are only slightly larger than the centrifugal pumps alongside. This, of course, is possible because of the high speed at which they operate and the type of unit, employing one motor to drive two compressors. The motors are of the engine type having the flywheel effect incorporated in the rotor so that no additional flywheel is necessary. The use of synchronous motors for driving ammonia compressors is steadily growing. It not only provides an excellent means of driving this type of equipment but makes a highly desirable type of load for the central station companies because of its excellent power factor characteristics.

FIG. 4. WATER FROM THE SPRAY COOLER ON THE ROOF DRAINS DIRECTLY INTO THE AMMONIA CONDENSERS INSTALLED IN THE COMPRESSOR ROOM BELOW

The switchboard controlling the distribution of current for the entire plant is located at one end of the compressor room as shown in Fig. 3. It consists of five

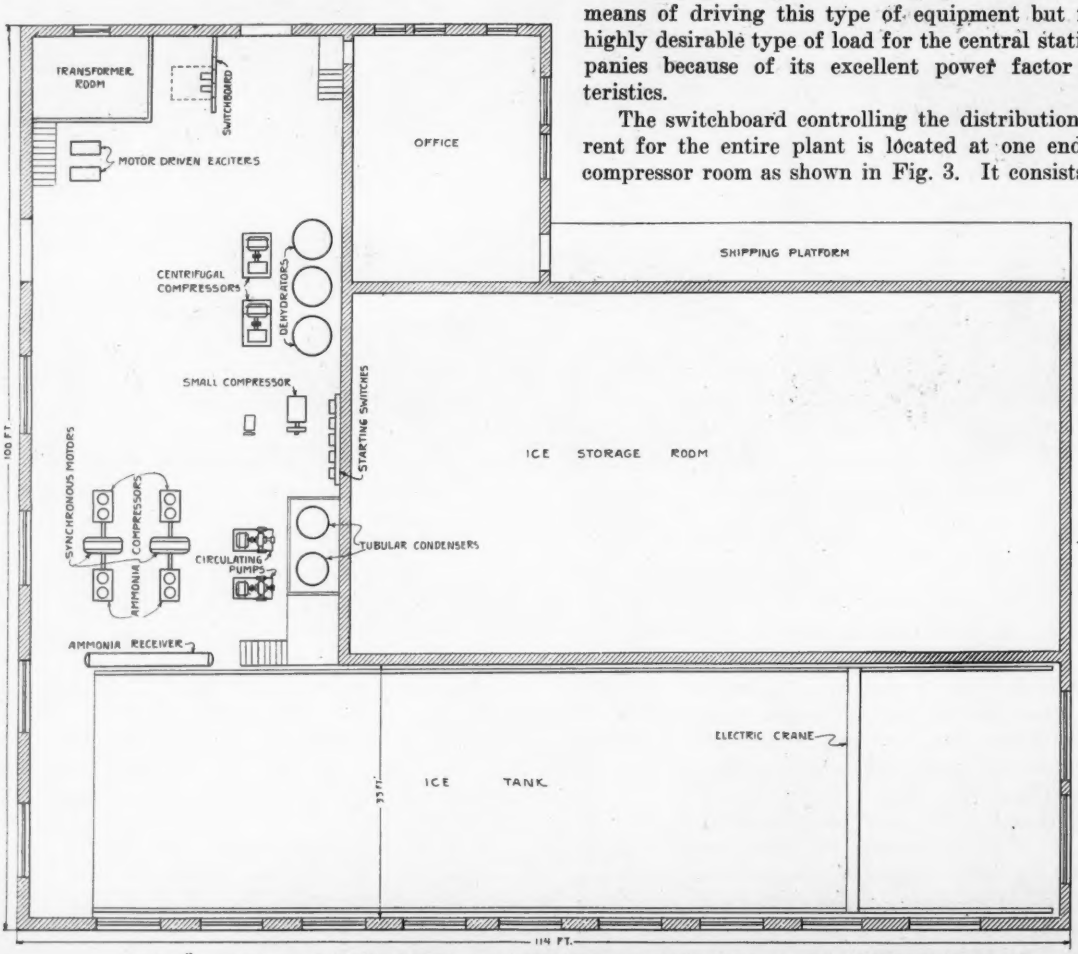


FIG. 3. THIS PLAN SHOWS THE ARRANGEMENT OF EQUIPMENT IN THE COMPRESSOR ROOM

panels, one for measuring the incoming power, two for controlling the two synchronous motors on the compressors, one for exciter control, and the fifth, a general distribution panel for 220-v. current. The rear equipment on the two synchronous motor panels is entirely enclosed by grille work so as to avoid accidental contact with the 2300-v. equipment. These panels are fitted with solenoid operated oil circuit breakers, remote controlled by push buttons from a point near the synchronous motors themselves. With the exception of the compressor motors, all other motors in the plant are 220-v. machines. Excitation for the compressor motors is furnished by 2 motors driven exciter units, each consisting of a 7½-hp., 2-phase, 220-v., 1740-r.p.m. motor direct connected to a 4-kw., 125-v., 40-amp. d.c. generator, all of Electric Machinery Co. manufacture.

Figure 2 is a view of the ice tank. This is a 75-t. tank, 15 cans per ton of ice, insulated with 4 in. of corkboard at the bottom, 4 in. of corkboard at each end and 12 in. of granulated cork at the sides. The ice making room is 33 ft. wide by 114 ft. long while the compressor room, at right angles to the ice making room, is 30 ft. wide by 63 ft. long. The tank is served by a two-motor, Detroit, single I beam crane, designed to handle 4 cans at a time. Raw water equipment for the freezing tank is of special design in which a special removable plug fitting is used in the air distributing system.

An interesting feature of this plant is the arrangement of the ammonia condenser equipment. The condensers, two of which are provided, are of the vertical tubular type, 45 in. in diameter by 15 ft. high and are the standard York Mfg. Co.'s design, modified to meet the engineer's requirements. Since these units are installed in the compressor room they are at all times subject to the attention of the engineer in charge. The heads of the condensers are at the roof line and the roofing is fitted around them.

Cooling Water from Spray Pond Flows Directly Into Condensers

Cooling water flows directly from the spray pond on the roof of the building into the condensers. In this way all piping between the roof and the head of the condensers is eliminated. After passing through the condensers, the water is collected in a concrete basin below the condensers, from which it is taken and pumped directly back to the spray pond on the roof by two Goulds centrifugal pumps rated at 700 g.p.m. against a 44-ft. head. These pumps are each driven by a 15-hp., 220-v., 2-phase, Wagner Electric Co. induction motor. With this arrangement of condensers, pumps and cooling pond, the piping and therefore the pumping head is a minimum. The spray pond is of the Cooling Tower Co.'s design, the entire spray being enclosed in a specially constructed louvre fence designed by the engineer.

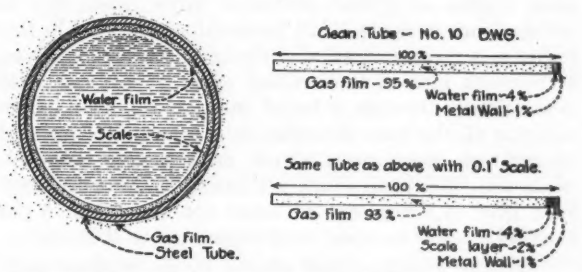
Dehydration of the air is effected by three dehydrators served by two blowers. These are placed along the inside wall of the compressor room as shown in Fig. 3 with the blowers directly in front. The dehydrators were designed especially by the engineer and are insulated with hair felt. The blowers are the Nash Hytor air compressors each driven by a Wagner 220-v., 25-hp. induction motor. They operate at a speed of 860 r.p.m.

On the whole this is a highly efficient plant, both as regards general design and construction and installed equipment. The president of the Premier Ice Co., A. C. Gruenewald, acted as his own building contractor in the construction of the plant, hiring most of the labor direct and purchasing most of the material. A portion of the work was sublet but the greater part was carried on under his own supervision. This gave him free reign in the selection of materials used and accounts for the excellent construction of the plant. Located in the center of a rapidly growing residential community, this plant with its low manufacturing cost will be able to meet the severest competition.

What Boiler Scale Does to Heat Transmission

By Huber O. Croft*

EFFECT OF SCALE on heat transmission in boilers is still somewhat of an unknown factor to the average engineer. The idea that even a thin layer of scale causes an extremely large decrease in heat transmission probably comes from the failure to appreciate the fact that even though the conductivity of scale is



Water temp. = 340° F. Steam press. = 118 lb. abs. Gas temp. = 1080° F. Tube temp.—Clean, 377°; scaled, 392°. Gas flow = 10 lb. per sq. ft. per min. Boiler rating = 90%.

GRAPHICAL REPRESENTATION OF RESISTANCE TO HEAT FLOW IN A BOILER TUBE WITH AND WITHOUT SCALE

extremely low, the resistance to heat flow offered by both the tube and the deposited scale in most cases is probably under 5 per cent of the total resistance to heat flow from the flue gas surrounding the tubes to the water in the tubes.

By far the largest drop in temperature is between the gas surrounding the tubes and the gas-side surface of the tube. The next largest temperature drop occurs on the water side surface of the tube while the temperature drop through the tube wall itself and the scale, if any, is smallest. The large drop in temperature on the gas side surface of the tube is due to resistance of a motionless gas film adhering to the tubes through which heat must pass by conduction. Likewise, the temperature drop on the water side surface of the tube is due to the motionless film of water through which heat must pass by conduction.

Actual tests on a 4-in. No. 9 B.W.G. boiler tube with an average wall thickness of 0.15 in. under actual

*Asst. Prof. of Mech. Engrg., University of Illinois. Abstract of paper presented before A. S. H. & V. E.

steaming conditions at 118 lb. absolute with natural convection producing water circulation through the tubes and with rates of gas flow comparable to boiler practice show the value of the heat conductivity of the metal in B.t.u. per sq. ft. per hr. with clean tubes to be 4.18 at 90 per cent and 6.68 at 225 per cent rating. Computed values of the heat conductivity with 0.1 and 0.2 in. of scale showed a heat decrease of 1.67 and 3.83 per cent respectively at 90 per cent rating and 2.99 and 5.98 per cent respectively at 225 per cent rating.

For a clean tube about 95 per cent of the resistance to heat transfer occurs on the gas side of the tube, 0.2 occurs through the tube and the remaining 4.8 per cent is caused by the water film on the inside tube wall. Obviously then, an enormous increase in resistance to heat flow between the two films through the metal of the tubes cannot affect the overall resistance to a very great extent.

Conductivity of Scale 6.7 Per Cent of the Conductivity of Steel

Tests with a scaled tube under actual steam generating conditions with 0.08 in. of scale showed the conductivity of this scale to be 21 B.t.u. per sq. ft. per hr. per deg. temperature difference per in. of thickness, or 6.7 per cent of the conductivity of steel. The density of this dry scale was approximately 140 lb. per cu. ft.

Bulletin 11 of the University of Illinois has often been quoted as giving extremely large losses due to scale. If an analysis of all the results presented in this bulletin is made instead of collecting a few high values, a thorough idea of the average effect of scale on heat transmission through a boiler may be obtained. Considering all the tests presented as a whole, 53.5 per cent of the tests show losses of not more than 6 per cent, while the 1905 tests which are probably the most accurate, give 84.6 per cent of losses not more than 6 per cent with scale varying in thickness up to 0.09 in.

Resistance to heat flow offered by an ordinary scale formation in a boiler tube is an extremely small portion of the overall resistance of the flue gas to the water in the tubes. Therefore, a relatively large increase in scale thickness can have but little effect on the overall coefficient of heat transmission where heat transfer occurs by convection and conduction and where radiation from a fuel bed is not present.

Cylinder Oil Should Fit Conditions

FOR LUBRICATION of valves and steam cylinders of engines and pumps oil should be chosen according as low-pressure, high-pressure or superheated steam is to be used. High pressure and superheat call for greater lubrication, which may, in general, be had from the darker oils.

In low-pressure cylinders, especially where wet steam is encountered, light-colored cylinder oils are preferred, frequently compounded with animal oil to avoid washing off the cylinder walls. Such oils will atomize easily and readily emulsify with the water, hence oil will be difficult to separate from the exhaust steam. For such conditions, a heavy black mineral oil may fail to atomize properly and will be liable to enter the cylinder in globules and be washed away by moisture in the steam.

When using high pressures and temperatures, thick, heavy oils are generally best. While a small percentage of animal oil promotes emulsification, this may be objectionable where exhaust steam is used for process work, especially if the condensate is used for ice making. In such cases straight mineral oil should be used, even though oil consumption will be greater, as all of it can be separated out from the steam and condensate. Also where condensate is used for boiler feed, as in marine practice, no animal oil should be used, as some is liable to reach the boiler surfaces and cause trouble.

Introduction of cylinder oil into the steam is important, so that thorough atomization may be secured before the oil reaches the valve and cylinder surfaces. Oil should enter the steam pipe well ahead of the valve chest, the distance being greater the heavier the oil. Dark, heavy oil fed close to the cylinder will fall to the bottom in large drops and may form gummy sludge which will cause piston rings to stick in their grooves. Using the same oil from a common oiling system for bearings and cylinders of high-pressure prime movers is bad practice for seldom is the one oil suitable for both purposes and the point and rate of application for the cylinders can be better obtained by a separate system feeding into the steam main.

For small non-condensing engines the U. S. Government specifications are as follows (though the same oils are suitable for condensing engines and for a moderate degree of superheat, where jet condensers are used): Well-refined petroleum compounded with 5 to 7 per cent of acidless tallow or lard oil. Flash and fire points not under 475 deg. F. Viscosity at 210 deg. F. from 120 to 150 sec. (Saybolt). Pour point not above 60 deg. F. Precipitation not over 0.5 per cent from a mixture of 10 per cent lubricating oil and 90 per cent standard naphtha. Acidity not over 0.4 per cent, calculated as oleic acid (equivalent to 0.08 per cent potassium hydroxide).

Where straight mineral oil is required, two grades are specified, both to be well-refined petroleum oil without compounding. For grade 1, flash point is to be 475 deg. F. or higher; viscosity at 210 deg. 135 to 165 sec. (Saybolt). For grade 2, flash point, 525 deg. or higher; viscosity, 180 to 220 sec. (Saybolt). For both grades, pour point is to be 60 deg. F. or lower; precipitation not over 0.5 per cent and carbon residue not over 4.5 per cent by Conradson tester.

Clean oil is, of course, necessary as dirty oil defeats the purpose of lubrication.

Where hard finish of a concrete floor has been worn away, it may be treated with a cement hardener, one form being fluor-silicates, dissolved as directed on the package, and applied several times, allowing each application to dry before the next is used. Worn out places may be given an extra application. Another material is water glass, which can be bought in liquid form at 40 deg. Baume and should be diluted with equal quantity of water. This should penetrate the concrete when applied, no liquid being allowed to remain on the surface to form a skin as it would crack on drying and subsequent finishes will not hold firmly on it.

Rigid Container for Orsat

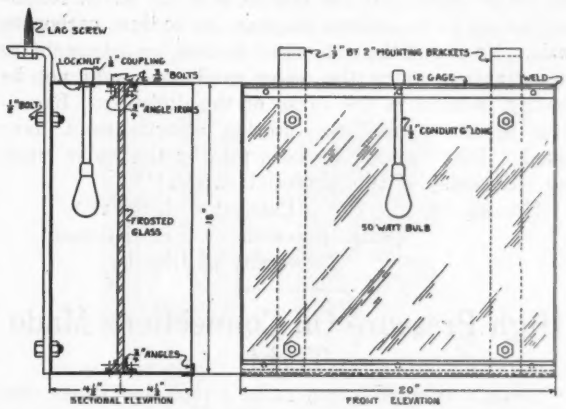
INTIMATE and accurate knowledge of furnace conditions is available primarily through intelligent use of precise instruments. In this respect, constant recourse to a gas analyzer serves to provide a goodly portion of the knowledge desired and as a result a better economy and a greater efficiency repay the efforts put forth.

Permanent installations have the disadvantage of delicate parts being exposed to unfavorable operating conditions as found in practically all boiler rooms, with the result that the maintenance of the instruments becomes a matter of prime importance with the added disadvantage, psychological if not concrete, that the engineer has instilled within him an element of doubt as to the accuracy of his tests. The use of the Orsat device, portable in nature, renewable in parts, and its supreme adaptability to a miscellany of boiler, boilers or gas analysis, makes it a very important adjunct to boiler room equipment; but the use of an Orsat device in the boiler room demands the same infinite care in its use, installation and operation as the best of permanent instruments. Gas lines must be free and clear, leaks eradicated and proper lighting employed to determine properly the meniscus of the liquids and resulting readings. It is this last item that concerns us at this moment.

Proper location of the Orsat is determined by its availability to the furnace under test, by its convenience in height to the engineer making the test, by the rigidity of its installation and by provision of good lighting. Naturally the closest point is the best and at such a height that the liquids of the apparatus will be on a line with the average engineer's eyes. Rigidity is easily secured and the lighting accomplished as follows: From 12 gage stock, construct a cabinet 9 in. deep to take a glass 18 by 20 in. The cabinet proper to consist of a back, sides, top and bottom but no front. The joints to be welded and the seams ground on an emery wheel to give a workmanlike appearance.

Having constructed the cabinet, a ¾-in. angle iron is fastened to the bottom front to hold the device in place; 4½ in. from the front on top and bottom, two ¾-in. angle irons are bolted in place with space between the two pairs to take extra heavy window glass which runs about ⅛ in. in thickness; $\frac{3}{16}$-in. bolts are used throughout and three of them to each angle iron. A hole is cut in the center of the rear portion on top to take a ½-in. conduit, four more in the rear (two on each side) to take ½-in. bolts for mounting and the main portion of the cabinet is complete. The next step is to construct a light unit which consists of a 50-w. mill type light, a brass shell socket with ½-in. opening, a 6-in. piece of conduit which will have a locknut screwed to full depth of the threads and extend through the hole in the cabinet to take a ½-in. coupling. This completes the lighting unit to the point of connection to supply circuit.

When the light unit is completed the rear half of the cabinet interior is painted white and the remainder finished in black or any other boiler room color. The glass is then frosted, as this part will be to the rear and well protected, and installed between the two pairs of center angle irons and the Orsat set in place for such tests as is desired and under such conditions that permit it to be read to the finest degree through diffused lighting, making it a pleasure to use this valuable instrument.



CONSTRUCTION OF 9 BY 20 BY 18-IN. METAL CABINET OF WELDED SHEET STEEL WHICH MAKES CONVENIENT HOUSING FOR ORSAT DEVICE

Aurora, Ill. E. J. MORRISSEY.

Feed Water Causes Caustic Embrittlement

"FORGED DRUMS Promote Safety," by J. L. Cox, in the July 15 issue, interested me greatly. This article was well written and showed conclusively the necessity, in drums under high pressures, of freedom from riveted seams.

In summing up the work which has been conducted along the lines of embrittlement, the author refers to a paper delivered at the Chicago Meeting of the National Board of Boiler and Pressure Vessel Inspectors in 1926 by Mr. Kriegsheim, and states "it was shown that drifting of rivet holes, high pressures used in riveting, excessive calking and extra thickness of metal in the seams which produce unequal expansion, and working of steel plates at blue heat are all causes of intercrystalline fracture."

I have made a careful study of the paper referred to, and fail to find that Mr. Kriegsheim has shown these facts to be so. He does not show a single instance where any one of these factors or group of them has caused intercrystalline fracture. He has very well defended his assertions that they may be the cause by quotations from various sources, many of which do not pertain to the subject and many of which date back into the nineties. Some of the facts given in this paper are gross exaggerations, and in more than one instance the conclusions drawn are not correct.

To the engineer who has a plant which may have potential trouble due to water, the statement that these other factors have been shown to be causes of embrittlement is misleading and may cause him to ignore the water situation and bring trouble to himself and plant.

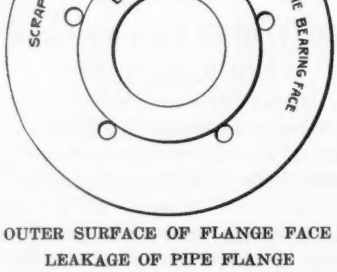
I have personally investigated embrittlement failures in over a dozen power plants in the last year alone. In some of these, explosions were miraculously prevented by the timely detection of the real trouble. In all cases the boiler water did not meet the A. S. M. E. recommendation as to sodium sulphate to sodium carbonate ratio. No embrittlement case has ever been brought to my attention where the water condition could not be readily isolated as the cause of the difficulty. Executives of the plants encountering embrittlement have asked, "Why haven't we been told by the water treating companies of this potential danger?"

Urbana, Ill. FREDERICK G. STRAUB,
Special Research on Embrittlement,
University of Illinois.

High Pressure Oil Connections Made Tight

NEARLY everybody can make a pipe and flange connection to hold pressure up to 100 lb., but to make tight connections to hold from 100 lb. up takes a little more skill and time.

We have an oil pressure piping which must hold 200 to 300 lb. and not leak; the pipes are flange connected.



SCRAPING OUTER SURFACE OF FLANGE FACE PREVENTS LEAKAGE OF PIPE FLANGE

The way we proceed is as follows: good threads are cut on the pipe, cleaned with a brush, oiled and screwed tight in the flange, then unscrewed, cleaned again and a little shellac painted on the threads; screwed on again tight, unscrewed once more, another little painting of shellac on the threads and the flange screwed on "real tight" to stay. Thus we have forced the threads one on to the other, there are no high spots, they have the same shape and the shellac covers positively any little space where oil could leak.

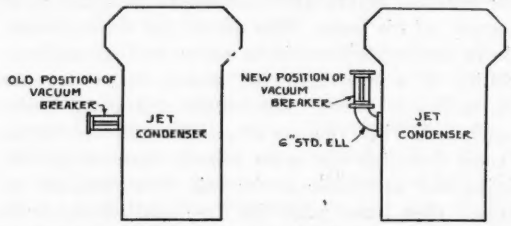
For the flanges, from the holes to the outside edge they are scraped with the sharpened end of a flat file, until the tool marks have disappeared, leaving the inner bearing face of the flanges a few thousandths of an inch higher than the rest. When ready to connect we put a thin coat of shellac on both faces and bolt tight.

Formerly we used paper gaskets to cover the whole flange but they were not successful because any slight dent on the flange caused a leak; it also seemed exceedingly difficult to have flanges that would not either warp or fail to come together perfectly under the bolt pressure. A single ring of paper on the flange inside of the bolts was not as good as the foregoing way of scraping.

Clarkdale, Ariz. CHAS. LABBE.

Operation of Vacuum Breaker Improved by Vertical Setting

CONSIDERABLE trouble was experienced with a vacuum breaker which had been attached horizontally to the side of our condenser. It frequently would not close



CHANGE OF POSITION FROM HORIZONTAL TO VERTICAL IMPROVES OPERATION OF VACUUM BREAKER

itself and had to be closed by hand when starting up and also at times when the vacuum would be broken on account of high water.

To overcome this, a 6-in. standard ell was interposed between the vacuum breaker and the condenser, giving the former a vertical position instead of a horizontal one. In its new position, the vacuum breaker worked perfectly.

Newcastle, Ind. NELSON HOWARD.

Editor's Note—See page 1006.

Repairing a Blowoff Cock

AFTER YEARS of service, the plug of the blowoff cock twisted off one day. Luckily there was a gate stop valve between the plug cock and the boiler which prevented loss of water and a consequent shut down when the plug failed. The gate valve stopped most of the water but it could not be closed tight so the blowoff pipe was capped. After nearly scalding himself removing the cap preparatory to blowing off, the engineer replaced it with a plain coupling to which a small stop valve had been attached. This small stop valve permitted the pressure to be relieved before the blowoff pipe was opened up.

Not having a lathe available the plug, to replace the broken one, was made by hand, with the use of a hacksaw, emery-grinder and file, from an old casting. This

was fitted to the cock body by the use of some bright blue paint, after which it was ground in with silica sand and oil. After the hole in the plug was drilled and filed out and the head squared for the reception of the wrench, it was fitted with a spring washer and nut and served perfectly in place of the broken piece.

Indianapolis, Ind. JACK BOSTON.

Comments on Proper Water Treatment

IN REGARD to Mr. Carmichael's answer to my recent letter as published on page 694 of your June 15 issue, the writer believes that it will be of interest to your readers if he gives a few more facts pertaining to sodium aluminate as applied to this problem.

In the first place Mr. Carmichael used the best possible method for the chemicals he had to work with. By using caustic soda instead of lime on a low sulphate, high bicarbonate water, considerable free sodium carbonate was formed which required the acid salt iron sulphate to keep the soda ash concentration from going too high and to form the required sodium sulphate.

By using sodium aluminate he could have obtained better reactions with lime and soda ash than he could with caustic soda and iron sulphate without producing an excess of sodium carbonate and sodium sulphate. This would have meant a considerable saving in cost of chemicals and a big reduction in soluble salts.

Then if there was not sufficient sodium sulphate in the boiler water this salt could be fed directly into the boiler in just the required amount. The writer has found this system to be much cheaper and more satisfactory where additional sulphate radical was needed in the boiler water. Commercial sodium sulphate is available on the market at a very low price.

Chicago, Ill. H. A. KERN.

THE WRITER agrees with Mr. Kern as to the formation of sodium carbonate, when using caustic soda instead of lime and soda ash. The operating conditions of this plant, however, had to be taken into consideration when treating the water and as the softener was 100 per cent over-rating at peak loads, it was necessary to reduce the precipitated suspended matter as much as possible in the softener.

As mentioned in my article published in the May 1 issue, the treatment was changed from lime-soda ash to caustic soda. With this change, a chemical treatment was had for the maximum precipitation of the scale-forming ingredients. Furthermore, on account of the over-rating of the softener when lime and soda ash was being used, the suspended matter resulting through the precipitation of the hardness did not have sufficient time to settle and in consequence the larger portion of this precipitate was carried over to the filters, resulting in the overloading of this equipment and materially affecting their functioning and capacity. As mentioned above, the precipitated suspended matter was very much lessened by the use of caustic soda as compared to lime.

As to the advisability of using commercial sodium sulphate for obtaining the proper amount of sulphates in the water, we use this and find it very satisfactory. However, in a case as at this plant where lime and soda could not be used satisfactorily, ferrous sulphate not only supplied the necessary coagulant, but also the proper amount of sulphate, which in turn formed sodium sulphate. On a cost basis alone, ferrous sulphate is cheaper than sodium sulphate, the former being approximately $15.00 per t. and the latter $30.00 per t. Furthermore, the magnesium was fully precipitated with the caustic soda which the writer understands is one of the functions of sodium aluminate.

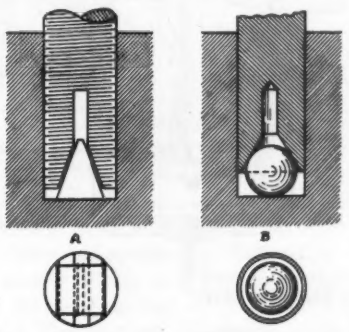
As a summary, the writer cannot see the advantages of sodium aluminate at this particular plant for the following reasons:

1. Lime and soda ash could not be used on account of the over-rating of the softener.
2. Ferrous sulphate supplied not only the coagulant, but also the sulphate at a cheaper cost than with the use of sodium sulphate.
3. Caustic soda greatly decreased the amount of precipitated suspended matter which was necessary in order to have the filters function properly.

Pittsburgh, Pa. D. C. CARMICHAEL.

Loose Studs May Be Wedged Tight

TWO OF THE studs in an engine cylinder had become loose and it was found impossible to screw them home tightly enough to prevent their working loose whenever the cylinder head nuts were removed.



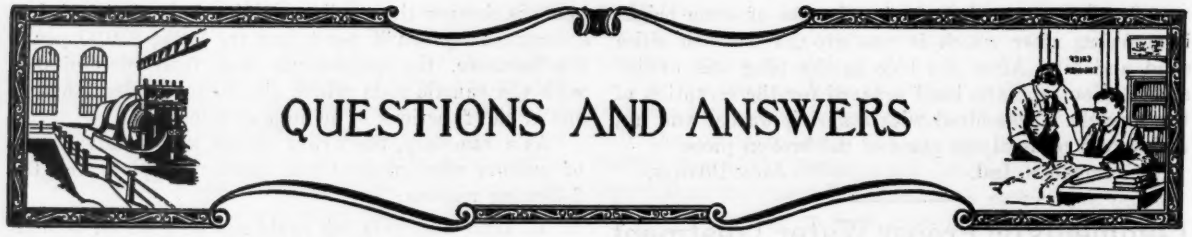
DIFFERENT METHODS OF TIGHTENING LOOSE STUDS BY WEDGING

The troublesome studs were removed and slots sawed in the bottom ends of each. A thin file was used to enlarge the end of the saw kerf as shown at A in illustration herewith, to fit a small wedge 3 in. in length. The large end of the wedge and the bottom of the stud-hole were made smooth and were well oiled after which the wedge was set in place in the slot, and some No. 1 "Smooth-on" daubed all around the wedge, in the saw slot made in the stud and in the stud-hole. The stud with its wedge was then carefully screwed into the stuffed stud-hole. The wedge and "Smooth-on" functioned perfectly. Those two studs could not thereafter be removed without drilling them out.

Loose studs also may usually be tightened by smearing moist "Smooth-on" on the screw-threads and screwing the loose stud home, after which, if left undisturbed for a couple of days, the stud will usually become permanently tight.

Indianapolis, Ind. JAMES F. HOBART.

Another method of tightening a loose stud or pin is to drill a hole into the bottom end of the stud, countersink this as shown at B and place a ball from a ball bearing at the bottom of the hole. On screwing the stud or driving the pin, as the case may be, into the hole, the end is caused to spread by the ball which is forced into it.—Editor.

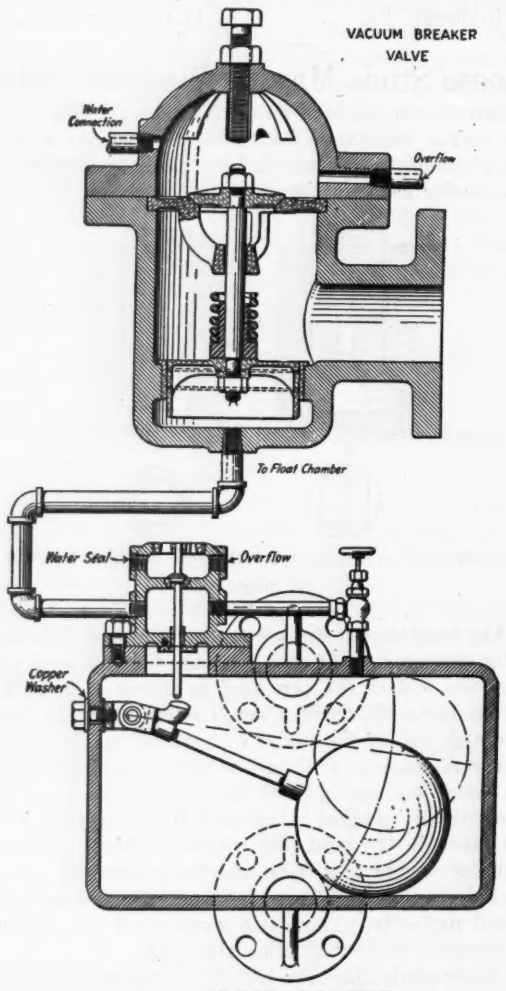


QUESTIONS AND ANSWERS

Vacuum Breakers

WHAT IS a vacuum breaker and how does it work?
A. F. C.

A. Low level jet condensers rely upon the removal pump to remove the injection water from the condenser body. If the pump fails, the condenser body will fill up with water very quickly and possibly back up into the turbine with disastrous results. To prevent this, low level jet condensers are provided with vacuum breakers which, if the water level in the condenser rises above a certain point, admit air to the condenser and destroy the vacuum.



VACUUM BREAKER SHOWING HOW OPENING OF PILOT VALVE CAUSES BREAKER VALVE TO RISE AND VACUUM TO BE BROKEN

As low level jet condensers are generally installed so that the flow of injection water depends upon the vacuum in the condenser, lowering the vacuum decreases the amount of injection water. If the trouble is merely a temporary overload on the removal pump, the pump is enabled to remove the surplus water and normal operation is resumed. If an actual break-down has occurred, the vacuum breaker admits air until the vacuum is destroyed, when the turbine or engine exhausts to atmosphere through the atmospheric relief.

The vacuum breaker shown in illustration consists of two separate parts, the lower containing a float actuated pilot valve; the upper the vacuum breaker valve proper. Both the pilot valve and the vacuum breaker valve are water sealed to prevent air in-leakage. The main vacuum breaker valve is normally held closed by the pressure of the atmosphere upon its upper surface. Attached to the lower end of the valve rod is a large piston having an area greater than the valve itself. Both sides of this piston are normally under condenser pressure. When the water level rises in the condenser, the float is raised and the pilot valve actuated, admitting atmospheric pressure to the under side of the piston. The piston, having a greater area than the vacuum breaker valve, forces this valve open against atmospheric pressure. As the disk is raised, air is admitted to the condensing chamber through the top of the breaker. The vacuum is then reduced, and the quantity of injection water decreased. If the removal pump is now able to discharge the excess water, the pilot valve will drop into normal position, and the vacuum breaker valve automatically closes. A spring and bushing upon the main valve rod prevents shock to the parts during operation.

Will Water in Breeching Cause Smoke?

DUE TO a leak in the concrete breeching between our boiler and stack, water from the lake has seeped into the passage and apparently causes a condition which sometimes results in smoke issuing from the chimney. The breeching is about 50 ft. long and is below the level of the lake and, although we pump this water out as soon as possible, the pump has failed at times, and the water has risen a foot or more in the breeching. I should like the opinion of engineers in regard to this question.

We seem to have plenty of draft in the furnace, although this has not been measured while the water was in the breeching. The stack is about 500 ft. high and the flue gases leaving the boiler have a temperature of around 500 deg. I do not think that the water has risen sufficiently to cut the draft down in the furnace appreciably. It may be, however, that the water in the breeching evaporates, lowering the temperature of the

stack gases, filling them with vapor and aggravating whatever smoke tendency there may be. Opinions of engineers will be appreciated.

Chicago, Ill. F. M.

Some Massachusetts Boiler Questions

FOLLOWING are questions that were put to me in an examination for engineer's license in Massachusetts. I would appreciate receiving answers to them.

1. What is provided on a Manning boiler to compensate for metal cut away for hand holes and man holes and how is the feed pipe supported in the old and new styles?

2. If two B. & W. boilers are run in a battery and all the feed water starts going into the boiler which has the heavier fire, what is wrong and what will make the feed go the other way?

3. How many calculations do you have to make to get the safe working pressure on a Manning boiler?

4. How is the total bursting stress on the outer sheet of the water leg calculated and how is the safe working pressure on this sheet figured?

5. What is used as radius for figuring the safe working pressure on the outer sheet of a water leg? Does it make any difference if the surface is staybolted or not? N. A. B.

A. There are no manholes on a strictly Manning boiler because there is not sufficient clearance to permit use of manhole plate. Modifications of the Manning boiler in which the lower part is either tapered or in which the entire height has the same diameter, such as the "Deane," have manholes.

Where manholes are employed, the loss of strength due to the cutting out of metal is compensated by the attachment of a "saddle" which has a strength equal to at least 94 per cent of the strength of the longitudinal seam.

For handholes not larger than 4 in. by 6 in., no attempt is made to compensate for loss of strength as this part of the shell is at least as strong as parts which have been weakened by rivet holes.

In the old type, the feed pipe ran horizontally across the inside of the boiler and was supported by pipe flanges on each side. The end was plugged so that this pipe could be readily cleaned out by removing the plug and inserting a cleaning rod. The top of the pipe was perforated to permit the admission of the feed water.

In the new type, the pipe does not extend through the boiler but stops at the entrance at the side where it is supported by a flange.

2. Other things being equal, the feed water would more easily enter the boiler which is being fired the lighter, because there is less resistance to its admission, due to the lighter pressure under which the boiler is operating. If, therefore, the water is not taking this natural course, the feed valve on the lighter fired boiler must be closed more than it should be, or the feed line otherwise restricted as by accumulation of sediment. The valve should be opened up or the feed line cleaned out, as the case may be, or temporarily, the feed valve of the more heavily fired boiler may be turned down slightly in order to change the flow.

3. The necessary calculations are four. They are as follows:

a. Bursting pressure of longitudinal seam.
b. Strength of staybolts.
c. Deflection of firebox shell between staybolts.
d. Thickness of O. G. sheet.

4. The Massachusetts method is based upon the staybolt pitch that is on each staybolt section of sheet. The seam of this sheet is very weak and is not considered as adding strength. The safe working pressure is based upon the unit stress in the staybolt.

5. The radius is not used in this calculation; the staybolt pitch determines the safe working pressure.

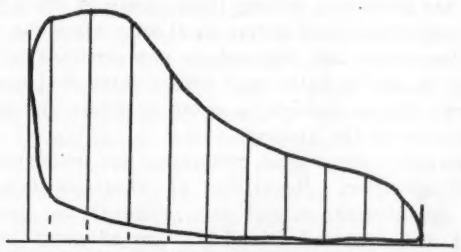
Since the sheet is staybolted it makes a decided difference; it is entirely dependent upon this staybolting.

Piston Valve Setting and I. H. P.

PLEASE let me know the following:

1. How do you set a piston valve?

2. How do you calculate the horsepower from an indicator card? E. A. C.



INDICATOR DIAGRAM SPACED FOR MEASURING MEAN EFFECTIVE PRESSURE

A. A piston valve is essentially a slide valve. Its surface is, however, cylindrical instead of flat and it moves in a closely fitting round seat. It may, therefore, be set in a manner similar to that used for the plain slide valves. The method of setting slide valves was described on page 208 of the Feb. 1 issue.

2. The indicated horsepower of an engine is best and easiest found by means of a planimeter, by which you can get the mean effective pressure directly from the card, and then use the formula P L A N ÷ 33,000, which will give you the indicated horsepower.

In this formula, P = the mean effective pressure in pounds per square inch; L = the length of stroke in feet; A = the area of the piston in square inches; N = the number of working strokes per minute.

If, however, no planimeter is at hand, the mean effective pressure can be found by computation. This is done by dividing the diagram in the manner shown in illustration, in which the lines drawn through the card represent the mean heights of ten equally spaced sections. Therefore, the first and last distances as drawn must each be one-half the width of the rest of the sections.

The object is to obtain the mean height of the 10 rectangular sections into which the diagram may be assumed to be divided. Each of the ordinates may be measured by the scale corresponding to the spring used, and the pressures so obtained added together; the result, divided by 10, will give approximately the mean effective pressure per square inch throughout the stroke, after which you can use the above formula to get the horsepower.

EDITORIAL COMMENT

Conventions

Conventions come and conventions go with each new year seeing an increased number being held in all fields of endeavor. Some of these conventions are for the purpose of business, some to discuss professional problems and progress and some are openly or clandestinely social. No doubt the maximum benefit is not obtained from them although it is safe to say that even the poorest of them do a considerable amount of good.

In this day and age, when practically all the papers which are presented during these meetings are printed and distributed either before or shortly after the meeting takes place and discussions are reported in full, there is in reality little need for an interested member to attend the convention in order to obtain the benefit of this part of the program.

Gradually the social programs are receiving increased attention. Regardless of what one may say about the information and data collected, the personal contact and renewed friendship are of great benefit. Increased social activities tend to increase this contact and give the delegates more of the personal touch which can be obtained only at the convention meeting itself.

Treatment of papers so that members interested can study them thoroughly before the meeting and thus offer constructive, well-prepared discussion is a necessity. Even this, however, is largely theory as attendance at one or two meetings will demonstrate. If it is well organized under the direction of an experienced chairman, discussion is choked off because of lack of time. If poorly organized under the direction of an inexperienced chairman, all the time will be spent on the first one or two papers, leaving the remaining two or three on the program to be passed up by a mere mention. In any event, the alternative and ultimate result is written discussion.

In other words, technical papers, long winded discussions, resolutions and voting are excuses for a convention; the real reasons are personal and social, to meet old acquaintances and make new ones, meet men who are prominent in the profession and for some, perhaps, a wanderlust and the desire to see new things and places. There appears to be little criticism of the increased social activity and small need for trying to hide the activities of the social section behind the cloak of other more businesslike committees.

The Operating Man and the New Plant

For a great many years power plant operating engineers, as a general rule, had little to do with the design or construction of new plants they were to operate. In recent years, however, it has become the practice of some central stations to have the operating engineers on the job in the capacity of observers while a new plant is being built. The industrial plant engineer is often in a better position to observe the construction of a new plant than his confrere in the central station, since such a new plant may be erected to replace the one he is already operating.

Among the more progressive industries, the suggestions often made by the operating engineer as to details of design of the new plant are of value. If he has been employed by the industry for any length of time, he will have a detailed knowledge of the operating problems that come up in that particular industry, which no plant designer or construction engineer can afford to ignore.

Suggestions by the operating engineer, however, are best made while the plant is still in the design state. If they seem practicable and economical, they can easily be incorporated at that time. In making such suggestions, the engineer must remember that designer and owner will consider them primarily from the economic viewpoint. Often a plan is proposed for the design of some detail of the plant that would greatly increase the ease of operation but might prove entirely too expensive over a period of years. On the other hand, as we have pointed out, the way to get a particular operation properly performed is to make the right way the easiest way to do it under the circumstances. From this viewpoint, in the arrangement of equipment and methods of controlling it, the suggestions of the operating man are often appreciated by the designer.

Having the operating engineer on the job during the plant construction has a further advantage in giving him the "atmosphere" of the new plant. Many things come up during construction that are difficult for the engineer to discover afterwards. Every engineer knows that piping, for example, does not always follow the blueprints to exact dimensions. There are many reasons for this and, if it is possible for the engineer to observe the installation of it, he will know the reasons for the changes. All designs must be modified to some extent on the job and, in the industrial plant especally, unforeseen difficulties may cause these modifications to mean practically revisions. Taken all around, it is good practice to have the man who is to make the machinery run offer suggestions for economical design, also watch its erection. Industries and central station companies that are wise enough to understand this reap the benefits in having operators with an understanding of the "atmosphere" of the new installation that they can seldom obtain so well in any other way.

Rural Electrification

In our middle western states, rural electrification offers one of the most promising fields for future expansion and is being made the subject of active investigation by practically all utilities companies.

Recently in Missouri, Dr. E. A. White, Director of the National Committee on the Relation of Electricity

to Agriculture, outlined the personnel and some of the accomplishments of the Missouri Committee. Three farm organizations, the State University and utility companies are represented on the committee. In fact, of the 21 members, 13 are from the University, 10 of these being from the College of Agriculture and two from the engineering college. The importance of electrification to the women has not been overlooked and their interests are looked after by a woman member from the department of Home Economics.

Public Utilities have but three representatives, seemingly a small number considering the importance of the public utilities in the program, but it must be remembered that these three representatives have the combined findings of their own well organized national organization, the N. E. L. A., behind them.

With such a committee engaged in research, experiments, cost finding and giving service where required, it is clear that the requirements of the farmer will be adequately taken care of, not only from the standpoint of the utility, but from that of the farm as well. Cost, of course, largely depends upon the load which can be developed. The possibility of 1000 kw-hr. per month per farm is not unreasonable and consumptions well below that would assure reasonably cheap power. Often the cost of local wiring exceeds the cost of bringing the transmission line to the farm and to be of practical benefit, full advantage must be taken of its possibilities.

Utilities can sell the farmer on rural electrification and create a demand but, if the farmers help to sell themselves and create the demand, the probability of their using the service to full advantage is greatly increased. Technically, there are no problems to be solved, beyond of course, the ever present engineering problem of lower construction and operating costs. The real problem is to create a sufficient demand to make electrification a paying proposition and in this connection efforts of farmers and agricultural men are of at least equal if not greater importance than those of the engineer.

Off Duty

Things certainly have come to a sad state of affairs when poor old Thor, God of thunder, must submit to the devastating leveling influence of standardization. Since time immemorial Thor reigned supreme, unhampered, fashioning his thunderbolts to suit his fancy or disposition. When he wanted to make them short and snappy and full of pep, he did so; if he chose to make them long and rumbling—well, that was his business. Was he not his own boss? Who was there to criticize his handicraft? Who was there to say whether his thunderbolts were suitable or not?

But alas, those days are gone forever, and Thor, like the brickmakers and the bakers and the hotel operators, must bow to the dictates of standardization, for the American Institute of Electrical Engineers has proposed a standard thunderbolt—lightning surge they call it. Hereafter when Thor desires to hurl a couple of thunderbolts for exercise, he will have to watch his step. Spec. No. A-3942 will call for a bolt, light green in color, 13,942 plus or minus 0.0003 ft. long, not over 15.37 in. in diameter, no square corners and with a rumble guaranteed to last 47 sec. Furthermore, it must bear the stamp of the board of underwriters.

Isn't that enough to make poor old Thor's red whiskers turn green? Imagine the old boy's feelings upon getting back a half gross of otherwise perfectly good thunderbolts marked "Rejected," merely because they failed to conform to standard as regards rumble.

Yet, despite the injustice of the thing we are afraid the old fellow will have to submit or quit his job. His methods are crude and out of date. The American Institute is not to be satisfied with slipshod work; it wants a uniform product it can rely upon.

In the testing of insulators and lightning arresters in electrical laboratories, it is highly essential that the lightning surge used be of the same character in all tests; that is, the voltage must rise to a definite value in a certain interval of time and must maintain a required value for another interval of time. The surge recommended must rise to its crest value in 4 microseconds and should not decrease more than 2 per cent in the following 10 microseconds. Notwithstanding the effectiveness of Thor's bolts, we are afraid he cannot make them accurate enough to meet these requirements.

This indicates a fundamental difference between men and gods, the capacity for improvement. Thor has been making thunderbolts ever since he first appeared in the pages of mythology but his thunderbolts have undergone no improvement or perhaps we should say—no refinement. Man, in the laboratories of our larger electrical companies, learned to make lightning only a few years ago and while his bolts are very much smaller than Thor's, each succeeding one is just a little bit better than the one before.

Not content with simulating lightning in the laboratory, he wanted to know what it was like. Now an ordinary lightning flash occurs in a few millionths of a second; to take a picture of such a flash, to show how the voltage rises in value and to determine its exact shape was, therefore, a formidable undertaking and we doubt if even Thor, who was in the lightning business, would have tackled it. But to the scientists in the laboratories this was just their dish.

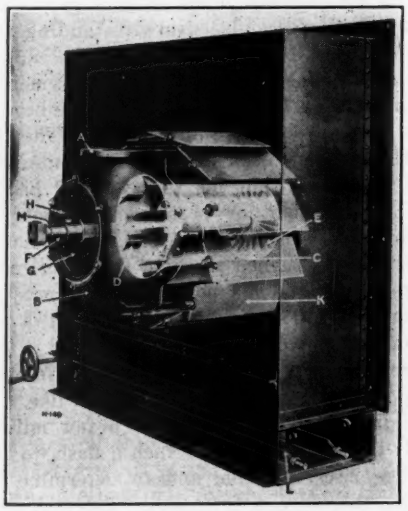
It was fortunate that just about the time they were ready with their lightning generator, Dufour, a Frenchman, had perfected what is now known as the cathode ray oscillograph. With this marvelously rapid instrument electric oscillations having frequencies of 200 million or more cycles per second can be photographed. Placed across a lightning arrester, during discharge, it will show exactly what takes place. It is of interest not only because it provides the lightning arrester engineer with a powerful new aid in the study of insulation behavior under conditions imposed by lightning surges, but is an example of what science can do in the realm of infinitesimal dimensions. In this instrument the electron stream which acts on the photographic plate, sweeps across the plate with a velocity as high as 12,000 miles per min., 200 mi. per sec.! Yet in the brief instant the stream impinges on any one spot on the plate, it photographs itself so that the engineer may study the phenomenon at leisure.

No, Thor was a great old boy in his day and gained worldwide reputation with the noise of his thunderbolt but he is not in it with the modern scientist. He would do well to throw away his hammer (Miolnir) and buy a Dufour oscillograph.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Riley Flare Type Burner

IN THE RILEY flare type burner shown in the illustration, pulverized coal, carried in suspension by primary or conveying air enters the chamber B through the flanged connection A. The stream is given a cir-



SECONDARY AIR WHIRLS INTO PRIMARY AIR AND COAL STREAM BEYOND E

cular motion within the chamber and enters the pipe C while revolving about its axis. Since this motion tends to cause the coal stream to travel in a zone adjacent to the inner surface of the pipe, vanes D are arranged to divert the stream toward the center. The coal then passes to the tip of the pipe, completely filling the space between pipes F and C. Vanes E break the coal streams into a number of stratified streams and divert these strata into a conical form or flare.

Secondary air, supplied under pressure from a fan, passes the dampers L which control the quantity of air flowing and is given a whirling motion in passing between the vanes K. The amount of whirl is determined by the position of these vanes. In general the direction of rotation of the secondary air is opposite to that of the primary air and coal but they are so designed that they may be set to give the same direction.

Mixing of secondary air with primary air and coal occurs beyond the tip of the burner E. The coal stream issuing from the tip in the form of a flare is violently whipped by the stream of secondary air issuing through the vanes K, the two streams being in rapid rotation.

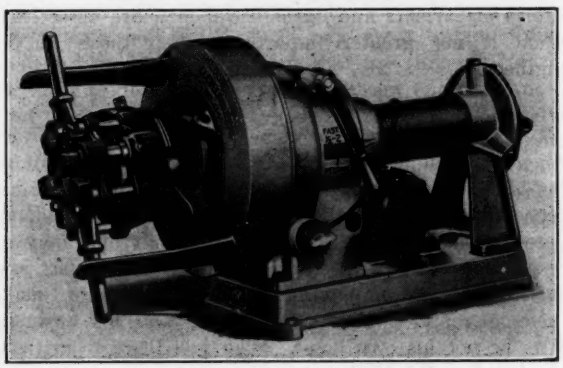
Impingement of the coal stream on the vanes E results in strata consisting of alternate rich and lean mixtures of coal and air. The rich portions of the stream ignite readily and act as kindling to the remainder of the mixture.

Initial ignition is secured by means of a kerosene torch. A 5-gal. tank of kerosene is mounted on the boiler front wall and a connection made between the pipe and point M on pipe F. Kerosene is then permitted to flow through this pipe into the furnace and is ignited by means of a waste torch. Primary air and coal are then introduced without any secondary air. Ignition of this rich mixture is instantaneous and without any puff. Dampers M are then gradually opened until the amount of secondary air is correct for the amount of coal being burned. The degree of the flame is adjusted by advancing or retarding the pipe F and rosette E.

This burner is a product of Riley Stoker Corp., Worcester, Mass.

New Power Boy to Handle Pipe Up to 4-In. Dia.

TO MEET the demand for a larger machine of the same type as the Oster No. 412 2-in. Power Boy, the Oster Manufacturing Co., Cleveland, Ohio, has brought



NEW 4-IN. PORTABLE PIPE THREADER

out the No. 414 Oster Power Boy, a 4-in. portable pipe threader, as shown in the illustration.

The No. 414 is built of the same aluminum alloy used in the No. 412 machine and weighs only 380 lb. The machine is 24¾ in. high, 47 in. long and 20 in. wide.

Driving power is furnished by a ½-hp. universal motor which will operate from any 110 or 115-v. lighting circuit, either direct current or alternating current, single phase and of any frequency from 25 to 60 cycles. Although the motor is of a variable speed type which automatically speeds up on the smaller sizes of pipe

and holds the required speed on the larger sizes, a two speed transmission is also used to increase production and power. A handy gear shift lever is provided on the side of the machine to enable the operator to change speeds quickly and easily.

The machine is designed to handle all sizes of pipe from ½ to 4 in. through its barrel and to drive geared die stocks from 4½ to 12 in. by means of an auxiliary drive shaft. Any square end or roller type pipe cutter of 2-in. capacity can also be driven. The pipe is held stationary in a three-jaw, self-centering chuck and the pipe tools are turned by the driving arms. Self-centering universal guides in the rear of the machine assist the front chuck in centering long lengths of pipe.

Non-Segregating Coal Distributor Helps the Stoker

COAL SEGREGATION in the stoker hopper and fuel bed is designed to be eliminated in a new device known as a non-segregating coal distributor now being put on the market by Rolland Gardner & Co., Rockefeller Bldg., Cleveland, Ohio.

Based upon the principle that coal falling vertically on the apex of a cone having a vertical axis, will divide so that every particle has an even chance of following

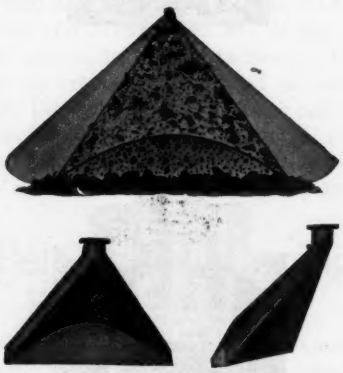


FIG. 1. CONICAL DISTRIBUTION SHOWING HOW LOWER PART OF CONE CAN BE CUT AWAY BY A VERTICAL PLANE THUS ALLOWING THE COAL TO DROP VERTICALLY

FIG. 2. A AND B. TWO VIEWS OF NON-SEGREGATING COAL DISTRIBUTOR SHOWING HOW SIFTING AND ROLLING OF FUEL IS AVOIDED

any straight line element down the surface of the cone and that a segment of a cone will act exactly in the same way, this device has been designed as a segment of a cone with the lower part cut away by a vertical plane. This causes each particle of coal regardless of size, weight or shape to be distributed equally along the many straight line elements of the segment because all have the same slope. No pile, therefore, accumulates on the surface of the cone tending to cause rolling of the larger particles to the sides as is the case in a straight chute, nor is there any sifting out of fines. The fuel proceeds through the distributor on to the grate in the same even mixture in which it came from the bin.

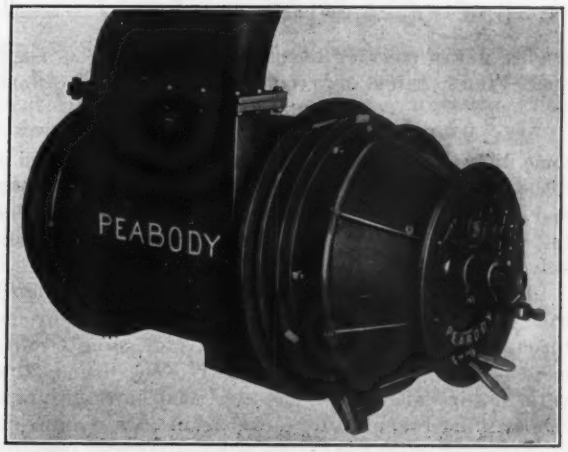
As shown in the Fig. 2, the non-segregating coal distributor is formed by boxing in the segment of hollow cone and providing an inlet for the coal at the apex and having the bottom open for distribution. A vertical plate is provided at the back where the distributor comes in contact with the boiler front in order to cause the coal to drop into the hopper in a straight line.

It is claimed that the use of this distributor aids in proper air distribution, and uniform combustion, and in accomplishing uniformly high CO_2 and low combustible in the ash. It also reduces stratification of the gases. Brick work and stoker parts, therefore, are conserved by the more even combustion accomplished and higher combined boiler and furnace efficiency, higher boiler ratings and lower furnace maintenance result.

Since there are no baffles or obstruction and the distributor is self-clearing in that the cross-sectional area increases rapidly from the apex to the discharge, there can be no clogging in the device.

Toronto Burner Designed for High Combustion Rates

DESIGNED ORGINALLY for the Toronto station of the Ohio River Edison Co. at Toronto, Ohio, a new type of turbulent burner has been placed on the market by the Peabody Engineering Corp., 110 E. 42nd



COAL IS SWIRLED INTO COMBUSTION AIR STREAM IN BARREL OF BURNER

St., New York City. In this burner, shown in the accompanying illustration, the coal is introduced through a large rectangular inlet into a screw-thread-vaned burner barrel. This interior arrangement is designed to give the coal an even distribution into the blast of combined primary and secondary air whirling through the barrel or body of the burner.

According to a report of tests on this burner made at Toronto, coal was burned at a rate of 5000 lb. per burner per hour with 6 burners operating on one boiler, and at a rate of 6000 lb. per burner per hour when the number of burners was reduced to four. The CO_2 reading was 16 per cent. This performance indicates combustion at the rate of 30,000 B.t.u. per cu. ft. of furnace volume per hour.

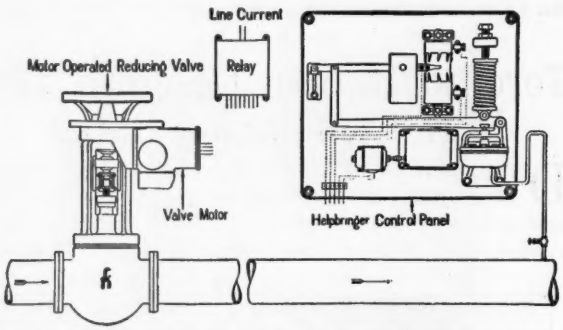
The steam output has reached a peak load of 325,000 lb. per hr., which is 445 per cent of the manufacturer's

capacity rating for the 2200-hp. boilers installed at this station.

This new burner, it is pointed out, can be used with any unit pulverizer or any type of feeder from a bin system. It is designed to make it possible to increase existing boiler plant capacities without any change in boiler equipment.

Helpbringer Control for Motor-Operated Valves

IN THE accompanying illustration is shown the Helpbringer electric control panel for regulating motor-operated pressure reducing valves. This device is designed for use where the main valve must be located



FINGER MAKES CONTACT ON ONE OF TWO DRUMS AS PRESSURE VARIES, THUS OPERATING VALVE MOTOR A SMALL AMOUNT

some distance from the point where reduced pressure is to be controlled. The panel, approximately 3 ft. long and 2 ft. high, is installed at some convenient point near the reduced pressure main and connected to the main valve motor by three electric wires.

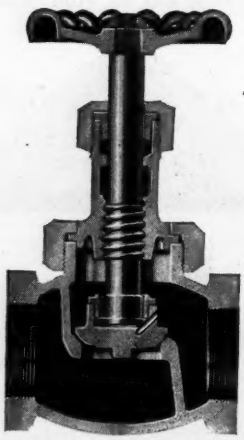
This control consists essentially of a pair of insulated contact drums, mounted on a vertical shaft and driven through reducing gears by a small, high-speed electric motor, which operates continuously. The drums turn very slowly—about 2 r.p.m. A small pressure pipe connects the low pressure steam main to a diaphragm chamber on the control panel; variations in pressure in the main are transmitted to the diaphragm and to a compound beam riding on the diaphragm and pivoted on knife edges. A compensating spring is used to balance excess pressure and a sliding weight permits adjustment of the beam. The floating end of the upper member of the beam carries an insulated finger that makes contact with the revolving drums. Each drum is fitted with a stationary brush contact connected through relays to the main valve motor. When the floating lever makes contact with the points on upper or lower drum, due to increase or decrease in the pressure in the main, there is a make-and-break action that produces intermittent applications of current to the motor on the main valve, closing or opening this valve to reduce or increase the flow of high pressure steam until the pressure in the main has been re-established.

Slight variation in reduced pressure causes immediate operation of the main valve motor, but this operation is only momentary and just enough to open or close the valve a slight amount. The drums revolve so slowly that the main valve motor circuit is broken part of the time and the pressure in the main has a chance to re-establish itself. These are the steps that would normally be made in manually controlling a reducing valve; in other words, the main valve would be opened or closed a slight amount and the operator would observe the effect on the reduced pressure, further opening or closing being made only if necessary. This feature is designed to eliminate "hunting" action.

The Helpbringer electric control for motor-operated reducing valves has recently been put on the market by the Schutte & Koerting Co., Philadelphia, Pa., and information is given about it in Bulletin 8-R-17.

New Bronze Valves for 300 Lb. Service

FOR STEAM PRESSURES up to 300 lb. per sq. in. and high temperatures, the O. I. C. extra heavy bronze union bonnet valves shown in the accompanying illustration are being marketed by the Ohio Injector Co., Wadsworth, Ohio, in both globe and angle types and in sizes from ¼ in. to 3 in. Body, bonnet and union nut of this valve are made of a special bronze designed to retain its tensile strength under high temperatures,



O. I. C. BRONZE VALVE FOR 300 LB.

while the stem is of special stem metal and the disc of high nickel bronze. Spindles are gland packed and equipped with ventilated, nonheating hand wheels. All sizes and styles are designed to be packed under pressure. In this valve a new method is employed for locking the disc to the spindle when regrinding so that the grinding pin will not drop out and so that the stem is not weakened.

Condenser Tube Cleaning Plug

CLEAN CONDENSER tubes are important to the economical operation of power plants and the Garlock Packing Co. has made a comprehensive research to develop a method to clean and scour condenser tubes with the least amount of labor, the result being a new type of condenser tube cleaning plug.

This Cord Plug is a patented article, manufactured of tenacious, resilient rubber and many long-brush cords,

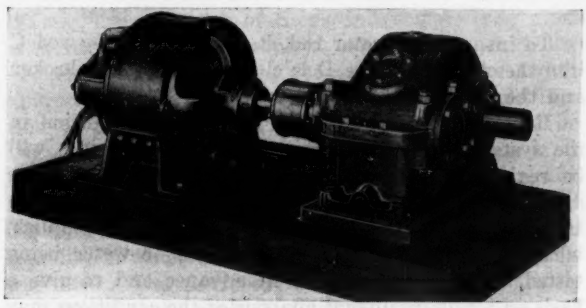
the cords being insulated from each other by a rubber film to prevent internal friction and give long life to the plug. The ends of the many staggered cords extend beyond the cylindrical wall of the plug, so as to set up friction against the inside surface of the tube, which causes a brushing or scouring effect when the

TUBE CLEANING PLUG IS OF RUBBER AND BRUSH CORDS

plug is forced through the tube by compressed air. It is claimed by the manufacturer that the plug always scours the tube down to the bright metal, never leaving a film that would retard heat transfer. This will give better vacuum and prolong the life of the tubes, as a clean tube is subject to less dezincification than a dirty one. The plugs are said to be rapid in their cleaning, thus reducing the outage hours and are also economical, as the purchase of special apparatus is not required. The air gun for shooting the plugs can be manufactured in the machine shop of any power plant.

Link-Belt Sykes Herringbone Speed Reducer

LINK-BELT SYKES herringbone speed reducer, illustrated below, designed for all classes of service has just been placed on the market. It is built for quietness of operation, high efficiency and ability to withstand shocks. Three standard units have been developed



TYPE S SINGLE REDUCTION UNIT ON MOTOR DRIVE

to cover a wide range of ratios and capacities. The single reduction unit, designated as type S covers ratios up to 10 to 1. Types D and DV are double reduction units. Type D is designed for heavy duty and ratios are from 10 to 1 up to 80 to 1. Type DV is a light duty reducer where ratios range from 10 to 1 up to 130 to 1.

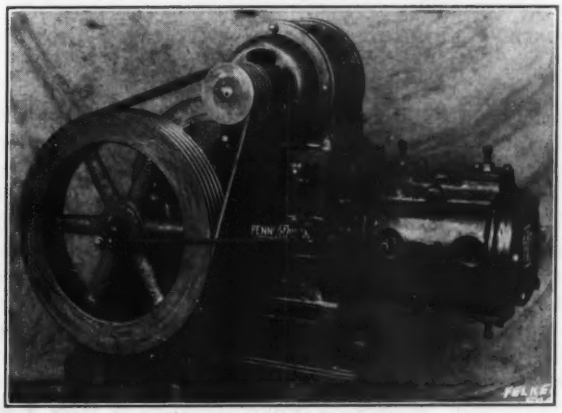
Link-Belt Sykes herringbone gears are used in this speed reducer. The teeth run continuously across the face of the gear to give a good bearing service with the several teeth engaged. Pinions are of heat treated alloy steel cut integral with the shaft.

The unit is designed with a minimum number of parts. Oversize Timken bearings are used. Gears operate in a large oil reservoir and bearings are splash lubricated. Special oil baffles are used at shaft projections to keep dust out and oil in. The housing is free from oil grooves and oil wipers.

Rigid construction insures proper alinement of parts and base plate, furnished when requred, maintains alinement of the reducer and its motor. Its maker, Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill., has issued Book No. 715 completely describing the new reducer and giving complete dimensions of the various types, capacities and price lists. It is manufactured at the company's plant, 2045 Hunting Park Ave., Philadelphia, and on the West Coast by the Link-Belt Meese & Gottfried Co., 19th and Harrison Sts., San Francisco.

Compact Compressor Unit Uses Texrope Drive

PENNSYLVANIA Pump & Compressor Co. of Easton, Pa., has recently placed on the market an arrangement for hoizontal double-acting air compressors which is designed for use where floor space is limited.



MOTOR MOUNTED ON COMPRESSOR, WITH NEW DRIVE, REQUIRES SMALL FLOOR SPACE

Heretofore, in a belt-driven unit, the closest spacing has been by the use of a short belt drive, where the motor is set ahead of the compressor, with an idler riding on top of the belt to provide the necessary tension and takeup.

The new drive employed for these compact units is the multiple belt drive known as the Texrope drive, manufactured by the Allis-Chalmers Mfg. Co., shown in the accompanying view.

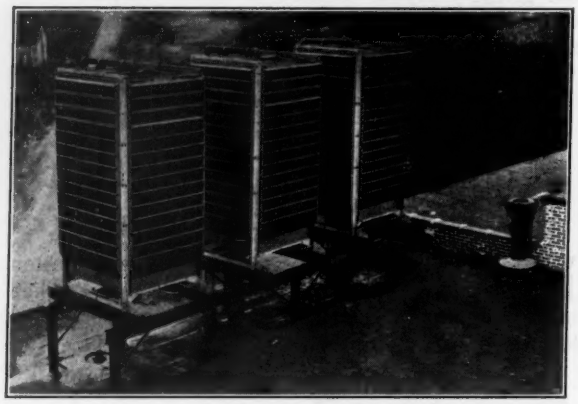
This consists of a number of flexible V-shaped rubber fabric belts, operating in grooved sheaves, similar to the English or separate rope drive.

This Texrope drive is designed to permit the use of very short centers and to eliminate slippage due to the V shape of the belt.

This eliminates the use of an idler; the motor, therefore, may be set up immediately ahead of and in the closest proximity to the frame of the compressor; where space is extremely limited, the motor may be mounted directly on top of the compressor frame. In the overhead type, as shown in illustration, it will be seen that no additional floor space is required for the motor.

Spray Cooling Tower of 100 G.P.M. Capacity

FOR COOLING CIRCULATING and condensing water in small installations where the required capacity is not more than a few hundred gallons a minute, a new spray cooling tower has recently been placed on



THREE OF THE NEW 100-G.P.M. SPRAY COOLING TOWERS INSTALLED IN SERIES

the market by Binks Spray Equipment Co., 3114—26 Carroll Ave., Chicago, Ill. It is designed for application to small refrigerating plants, Diesel engine plants, vacuum pans, transformers, air compressors and the like. It is made in units which have a maximum capacity of 100 g.p.m. each. As shown in the illustration, several of these units can be installed in series to give the required capacity.

The new tower is a combination of the spray system and the atmospheric cooling tower. Water to be cooled is brought in by the pipe at the top to a group of "Spra-Rite" nozzles. Pressure required is from 7 to 10 lb. at these nozzles, which are inverted and spray downward against the louvres. The unit is furnished with a collecting pan if desired, but installations without this pan is recommended to secure the better cooling effect due to the bottom draft. If installed on the ground, a cement basin can be used and if on a roof, a simple deflector to the downspout. The three units shown connected in series are installed without the pan.

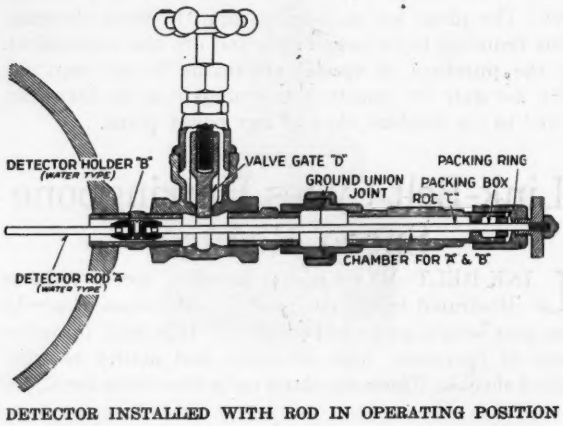
Each unit of the new tower is constructed of heavy galvanized steel beams, cross members and centering rods; woodwork is of cypress. Corner members are assembled at the factory and in erecting are bolted to cross members. Louvres are dropped into place and tie rods are screwed up with turnbuckles.

Each tower is 6 ft. square and 12 ft. high, requiring a floor space 6 ft. by 7 ft. 6 in. All towers are of these dimensions, irrespective of capacity, which is controlled by selection of spray heads for any given capacity up to 100 g.p.m. per tower.

Rice Detector Gives Record of Steam or Water Conditions

ONE PHASE of the service of Cyrus Wm. Rice & Co., Pittsburgh, Pa., in the treatment of feed water and in blowdown control, covers a means of detecting the constantly changing conditions in steam and water systems. This device is designed to give a continuous and readily accessible record of exactly what is happening inside the system in question, under actual operating conditions. To secure such a record, the Rice detector, shown herewith, has been developed and recently put on the market.

In this detector, a detector rod A is held in position, in the boiler, heater or other apparatus to be examined, by the detector holder B in such a way as to be exposed to the actual internal operating conditions. Holder B for the water detector is made of material that will resist any galvanic action, while detector rod A for water is a specially prepared and sensitized piece of steel whose characteristics are known. For steam exposures, non-ferrous metals are used in the rods, which have fins to provide large contact surface.



DETECTOR INSTALLED WITH ROD IN OPERATING POSITION

To inspect a detector rod, it is withdrawn by rod C into the chamber, valve D is closed, the union is broken and the rod is then exposed to view.

Rice detectors are designed so that any condition in the system, whether corrosive or deposit-forming, will be registered on the detector rod under full pressure and operation. They are intended to tell what water treatments are accomplishing or failing to accomplish, what impurities are in the steam, gas or water being tested, to point out trouble in advance and to give a basis on which intelligent analysis of the conditions may be based and corrective measures taken either with the working fluids themselves or with the equipment employing them.

THE GREEN BAY & MISSISSIPPI CANAL CO., Insurance Bldg., Appleton, Wis., is making plans for a new power plant at Kaukauna, Wis.

Merger Announced of Brown Hoisting Machinery Co. and Industrial Works

DIRECTORS of The Brown Hoisting Machinery Co., Cleveland, and Industrial Works, Bay City, Mich., have approved plans for a merger of the two companies, to be made effective when ratified by their respective stockholders at meetings which will be held in the near future. The businesses to be joined are both engaged in the materials handling industry, the physical properties, the standards of design and workmanship, and the personnel of the companies being similar.

The object of the consolidation is to render better service to users of material handling equipment by means of eliminating duplication or overlapping of product where it exists, by effecting economies in manufacturing and by concentrating in each plant that portion of the work which can be produced to the best advantage.

The Brown Hoisting Machinery Co. was founded in 1880 by Alexander E. Brown and has its principal plant occupying 9½ a. fronting on St. Clair Ave. in the City of Cleveland. The company also owns at Elyria, Ohio, 25 a. of land on which is situated a modern and completely equipped iron and bronze foundry.

Industrial Works was founded in 1873 by George C. Kimball, James Clements, E. Wells, and Charles R. Wells, and has a plant covering 29 a. consisting of 60 buildings, with over 440,000 sq. ft. of covered floor space.

The consolidation will join under one management over 2100 people and assets of approximately $13,000,000. The combined sales of both companies totalled over $7,700,000, in 1926. Both plants will be continued in operation, and no radical changes of any sort are contemplated.

AS REPORTED BY the latest issue of the Stone & Webster Journal, the Southern California Edison Co. recently found it necessary to acquire an additional tract of land at Long Beach, Calif. and to prepare for an additional steam plant of 1,000,000-kw. capacity. This required relocation of two steel fuel oil tanks, each having about 1,300,000 gal. capacity. It was necessary to move these tanks about 1000 ft. over a sandy level plain. The engineers of Stone & Webster, Inc., which is constructing this new plant, adopted the novel plan of constructing two dykes about 4 ft. high and 100 ft. apart extending the entire distance from the old location to the new location of the tanks. The space between these dykes was then filled with water to a depth of about 20 in. and the tanks were floated in this artificial pond the entire distance of 1000 ft. By drawing off the water they were gently settled on their new foundation which had been prepared before the pond was filled. The entire operation was carried out without straining the tanks and without starting any leak whatever in them.

THE CAMPBELL SOUP CO. plans the construction of a large boiler plant in connection with new factory units at Camden, N. J. The entire project is estimated to cost about $2,000,000. A. C. Dorrance is general manager.

Upper Tallassee Project Develops Rapidly

UPPER TALLASSEE DAM of Alabama Power Co. on the Tallapoosa River near Tallassee, Ala., on which 1000 men are working in day and night shifts, is being built on the fastest construction schedule ever undertaken by that company. Design is only about two weeks ahead of construction work.

The dam, on the site of which the first hydro-electric plant in Alabama was constructed in 1896 by citizens of Montgomery, is nearly 50 per cent complete. The original dam was destroyed by flood in 1919, rebuilt in 1924 and is now being increased in height from 36 to 57 ft. and in capacity from 8500 to 50,000 hp. The 25,000-hp. units to be installed will be the largest low head turbines thus far brought into the Southeast.

RECENT VIEW OF UPPER TALLASSEE DAM UNDER CONSTRUCTION

Present construction schedules, which were recently advanced to meet demands for power beyond previous expectations, call for the bringing in of the first unit early in 1928 and the completion of the project in June of that year.

News Notes

THE ASSOCIATED GAS & ELECTRIC CO., 61 Broadway, New York, is planning extensions in two large water power projects in Pennsylvania known as the Pliny and Deep Creek plants. Each plant has a rating at present of 24,000 hp., which will be increased by 12,000 hp. in each case.

THE WISCONSIN POWER & LIGHT CO., Madison, Wis., is said to be planning the construction of a new hydro-electric plant on the Wolf River near the Menomonie Indian Reservation, to cost about $300,000.

CHARLES G. OLSON, formerly of the main office of the Chain Belt Co., Milwaukee, has been transferred to the Detroit office at 8855 Woodward Avenue.

CUTLER-HAMMER MFG. CO. announces removal of its Cleveland, O. office from the Guardian Trust Building to the Guarantee Title Building, Suite 1905, where about

three times the space formerly used will give the facilities made necessary by increasing business.

EDWARD F. DEACON, formerly president of the Brecht Co., has been elected president of the Climax Engineering Co. of Clinton, Ia., succeeding George W. Dulany, Jr., who becomes chairman of the board of directors. W. E. Eberhart, Jr., was elected treasurer, succeeding M. M. Cruise of Chicago.

E. H. SCHMITZ has been appointed manager of the Pittsburgh district office of Riley Stoker Corp. Mr. Schmitz is a graduate of Massachusetts Institute of Technology, was in the combustion engineering department of the Sinclair Oil Co. and afterward with the Tennant Co., consulting engineers at Houston, Tex. Since 1925 he has devoted his time to experimental developments with the Riley Stoker Corp., hence is familiar with combustion practice and problems.

ATLAS CONVEYOR CO. has organized to manufacture conveyors and coal and ash handling equipment, with Percival K. Reed as chief engineer, L. G. Weygandt as eastern sales manager and E. A. Thumlert as general manager, all recently with R. H. Beaumont Co. Offices will be at 20 S. 15th St., Philadelphia.

THE ASHTON VALVE CO., Boston, Mass., announces with profound sorrow the death of Horace W. Rand on Friday, August 5 last.

CONNEAUT PACKING CO., Conneaut, Ohio, of which J. B. Riley is president, has just moved into its new factory and office building, constructed for its exclusive use in that city.

GRINDLE FUEL EQUIPMENT CO., Harvey, Ill., announces that W. R. Bean, formerly research engineer of the Eastern Malleable Iron Co., has entered its employ as vice-president and consulting engineer.

J. A. FRANKLIN, formerly of the Industrial Sales Division of Cincinnati Office, Westinghouse Electric & Mfg. Co., has been appointed Cincinnati district manager of the Kaestner & Hecht Elevator Co., effective August 1.

WESTERN POWER, LIGHT & TELEPHONE CO., has been organized with headquarters at Salina, Kan., to take over holdings formerly operated by Public Utility Investment Co., A. B. Leach & Co., and the Porter Fox Co., aggregating about $2,000,000.

MARCUS A. CURRAN of New York, at present assistant to vice-president of the Graybar Electric Co., has been elected vice-president and general manager of the Bryant Electric Co., Bridgeport, Conn., according to an announcement made by Walter Cary, president of the Bryant Electric Co. Mr. Curran assumed his new duties on September 1.

AFTER 25 YR. of service as president of Stevens Institute of Technology, from which he retired recently, Dr. Alexander Crombie Humphreys died at his home in Morristown, N. J., on August 14. Dr. Humphreys was born in Edinburgh, Scotland, in 1851 and during his career has been chief executive of fifty gas and electric plants. He held degrees from several universities, was former president of the American Institute of Consulting Engineers, the American Society of Mechanical Engineers, the American Gas Institute and had been president or prominent member of many other technical and scientific societies both in this country and in Great Britain.

BY CO-OPERATION OF C. L. Edgar, president, and R. E. Dillon, superintendent of the Generating Department, Edison Electric Illuminating Co., of Boston, arrangements have been completed whereby the students of the course in Fuel and Gas Engineering of the Massachusetts Institute of Technology will do field work and testing at the Edgar Station of the Edison Co. This course is intended to train graduate engineers and consists of one academic year of graduate study at the institute followed by six months' field work. The Edgar Station contains prime movers operating at both 1200 and 350-lb. steam pressure, is equipped with the latest combustion control devices and includes many of the latest developments in the power generation field. Thus the students in the Fuel and Gas Engineering course will be accorded an excellent opportunity for observing the detailed operation of a modern central station.

MERGER of The Gardner Governor Co., of Quincy, Ill., and The Denver Rock Drill Mfg. Co., of Denver, Colo., has just been announced, the new corporation to be known as the Gardner-Denver Co., with headquarters at both Quincy, Ill. and Denver, Colo.

This merger brings together two of the largest manufacturing companies in their fields, the products made being complementary to each other. For over 65 yr., The Gardner Governor Co. has built pumps, compressors and governors. From a small two-man shop started in Quincy in 1855 by R. W. Gardner, there has been a steady growth until today it furnishes employment to over 600 men. The Denver Rock Drill Mfg. Co. specializes in rock drills, drill steel sharpeners, scraper hoists, concrete breakers and allied accessories, with 20 branch offices in the United States, sales offices in England, Spain, Mexico, Chile, Australia, New Zealand, Canada, South Africa and Japan. Over 600 people are employed by the company.

J. W. Gardner will be chairman of the board of the Gardner-Denver Co. and W. H. Leonard, of Denver, will be president.

O. E. POOLE, SR., who had served the Dearborn Chemical Co. since September 1, 1903, as manager of its Peoria, Ill. branch, passed away at his home in Peoria, the morning of Aug. 1. Burial took place on Aug. 4. Mr. Poole was 71 yr. of age; while he had not traveled much for some years, he had actively directed the sales organization in his territory until a few months ago, when he suffered a stroke from which he did not recover.

THE PENN CENTRAL LIGHT & POWER CO., Altoona, Pa., operated by the National Electric Power Co., has purchased the Everett Light, Heat & Power Co., Everett, Pa., which has been operating its own local generating station.

LARS G. NILSON, Hoboken, N. J., has resigned his position as chief engineer of the Nilson-Miller Corp., to enter consulting engineering practice in the design and development of special machinery.

THE FALK CORPORATION of Milwaukee, Wisconsin, announces the opening of an office in Portland, Oregon, at 729 Terminal Sales Bldg., 12th and Morrison Sts., in charge of John Jurgensen, who has been in the company's New York office for 7 yr.

E. A. BALDWIN has been appointed general European manager of the International General Electric Co. with headquarters at Paris, France. Edgar A. Carolan, vice-president, at his own request has retired from active work and will reside in France, where he will be available for advice regarding the company's affairs.

ENGINEERING AND PURCHASING DEPARTMENTS of Byllesby Engineering & Management Corp. will have new quarters on the 8th and 9th floors of the Bankers Bldg., corner Adams and Clark St., Chicago, according to H. W. Fuller, vice-president. This building adjoins the Illinois Merchants Bank Bldg., 231 S. LaSalle St., where the offices of H. M. Byllesby & Co. and other departments of the Byllesby Engineering & Management Corp. are located. All communications should be sent as heretofore to the Illinois Merchants Bank Bldg., 231 S. LaSalle St., Chicago.

"QUALIFICATIONS AND DUTIES of a Safety Director in the Public Utilities" will be discussed by Charles B. Scott, general manager, Bureau of Safety at the opening session of the public utilities section at the sixteenth annual safety conference which will be held at the Stevens Hotel, Chicago, beginning Tuesday morning, September 27. Frank Smith of the United Electric Light & Power Co. will discuss ways and means of impressing executives and operating and designing engineers. On Wednesday morning discussion of first aid methods, safe practices in gas making, fire prevention for public utility companies will be held, with a luncheon for both public utilities and electric railway sections. On Thursday morning J. C. Sanderson of Sargent & Lundy, Inc., will discuss construction contractors' accidents on public utility properties, and Walter Wagner, Philadelphia Electric Co., will talk about elimination of high voltage hazards on customers' premises. There will be a general round table discussion before the session is closed and new and retiring officers will meet. George Opp of the Detroit Edison Co. is chairman of the section.

JUDGE ELBERT H. GARY, chairman of the Board of Directors of the United States Steel Corp., died on August 15 at his home in New York City. He was born near Wheaton, Ill., in 1846, graduated from Union College of Law in Chicago in 1868 and, after serving a few years as clerk in the Superior Court, was elected judge of Du Page County. In 1892 he became identified in the public mind with the steel business as a result of important services as general counsel in connection with several large steel companies. He was elected president of the Federal Steel Co. in 1898 and soon afterwards, when this company with several others was formed into the United States Steel Corp., became the executive head of the latter. He continued in this position until 1903 when he became chairman of the Board of Directors.

THE KANSAS CITY POWER & LIGHT CO., Kansas City, Mo., has just ordered from Westinghouse Electric & Manufacturing Co. a 10,000-kw. turbine generator. The turbine of this unit is designed to operate at 1200 lb. gage steam pressure and 725 deg. total temperature at the throttle. It will exhaust at 300 lb. gage. The generator is rated at 12,500 kv.a. unity power factor, 3 phase, 60 cycle, 13,200 v., 3600 r.p.m. The new unit will be installed in the Northeast Station of the company at Kansas City.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examination for second class steam engineman, applications for which must be on file with the Commission at Washington, D. C., not later than September 27. The entrance salary is $1500.00 a year. A probationary period of six months is required and the duties are to have charge of operation, maintenance and repair of a heating or power plant. Competitors will not be required to report for examination at any place, but will be rated on physical ability, training and experience. Full information can be obtained from the Commission at Washington, D. C., or the secretary of the board of U. S. Civil Service examiners at the post office or customhouse in any city.

The Commission also announces open competitive examination for Junior Engineer, for which applications must be on file not later than October 1. Entrance salary is $1860.00 a year and competitors will be rated on general physics, mathematics, general engineering and one optional subject.

DRY QUENCHING of coke without the use of water, as developed by Sulzer Bros. of Winterthur, Switzerland, and widely used in Europe is to be introduced in America by the Dry Quenching Equipment Corp. of which George E. Learnard, president of the International Combustion Engineering Corp. is chairman of the board of directors, H. D. Savage is president, G. G. G. Hunter, vice-president, and George H. Hansel, treasurer. The first unit of this type was installed for the Rochester (N. Y.) Gas & Electric Corp. and is in satisfactory daily operation, sensible heat of the coke being utilized for making steam. Walter Sennhauser of the Sulzer Bros. organization will come to the new corporation as chief engineer.

THE MIDDLETOWN (CONN.) GAS LIGHT CO. has been reorganized following its acquisition by the Connecticut Light & Power Co. J. Henry Roraback of Canaan, Conn., is the new president; Irving W. Day of Waterbury, vice president, and C. L. Campbell of Hartford, secretary and treasurer. These officers with J. Gordon Baldwin and Earle C. Butler comprise the directors. All are officials of the Connecticut Electric Service Co.

THE STATE INSANE HOSPITAL AT TOPEKA, KANSAS, is installing a new 275-hp. Murray boiler which will be fired by Jones underfeed stokers. C. L. Woodington is chief engineer.

H. O. SWOBODA, INC., of Pittsburgh, Pa., has been retained to determine whether it will be more economical for the school district of Altoona to generate electric energy in its own central light, heat and power plant or to purchase that energy.

THE NORTHERN STATES POWER CO., Minneapolis, Minn., has begun preliminary work on its proposed 27,000-hp. hydroelectric plant at Chippewa Falls, Wis.

ON AUGUST 4 the last concrete was poured in the Horse Mesa Dam, part of the Salt River Valley hydro electric project in Arizona. The power plant is not yet operating under full head as the Tainter gates are now being installed. At the present time the capacity of the plant is about 35,000 hp., which will be raised to 40,000 under full head.

THE NEW ORLEANS PUBLIC SERVICE CO., New Orleans, La. has adopted an improvement program totalling

$55,000,000 over a period of ten years, covering electric light, power, gas and transportation facilities. This includes the work now nearing completion on an addition to the power plant on Market St., where a new 30,000-kw. electric generator is being installed, increasing the total capacity of the plant to 108,000 kw. Completion of this unit is scheduled for early in the fall.

PERMITS AUTHORIZING THE CITY OF TACOMA to appropriate 600 second feet of water of the south fork of the Skokomish river and to store 22,000 acre feet in the Skokomish reservoir were recently issued by R. K. Tiffany, state hydraulic engineer. The project is part of the Cushman development. Work is scheduled to begin in August, 1929 and to be completed by August, 1932. The capacity of the development is estimated at 35,000 hp.

Books and Catalogs

NON-TECHNICAL CHATS ON IRON AND STEEL. By LaVerne W. Spring. Frederick A. Stokes Co., New York, 451 pp., $4.00.

It is seldom that a technical author has the knack of abandoning his technicalities for a simple narrative style, yet remaining true to facts and figures and at the same time making the story as interesting as a novel.

From the crude implements of prehistoric man to the use of the X-ray for X-raying castings and forgings, the history of iron is complete. Details have largely been omitted but their omission serves to emphasize the main facts. For those sufficiently interested to go farther into technicalities and details numerous references are given.

The author has been intimately connected with the steel industry for many years, first in the laboratories and later in the rolling mills. Still later work with gray and malleable cast iron and cast steel brought him in contact with probably every phase of the industry. He is now chief chemist and metallurgist of a large industry so that the book is assured the authenticity so often lacking in works of this kind.

DESCRIPTIVE GEOMETRY, by C. H. Schumann, Jr. First edition, 250 pages, size 6 by 9, cloth, $2.50. New York, N. Y., 1927.

DRAFTING FOR ENGINEERS, by Carl Lars Svensen. First edition, 364 pages, size 6 by 9, cloth, $2.75. New York, N. Y., 1927.

Two excellent books, both of which should be of great value to draftsmen, engineers and students. Although written by different authors and published separately, we are listing them here together because we believe that anybody interested in one will be interested in the other. The position which drafting occupies as a fundamental course of study for the profession of engineering gives it at once a place of prominence and importance, and a good book on the subject is welcomed. But the basis and theory of mechanical drafting is descriptive geometry and for this reason the volume on this subject by Mr. Schumann forms an excellent companion volume to Mr. Svensen's book.

Mr. Schumann is assistant professor of drawing at Columbia University and his book is the result of his teaching experience there for some years as well as the outgrowth of a departmental policy covering many more. An effort has been made to present the subject from the student's viewpoint and to describe the problems with such clarity as to render it less necessary for the instructor to supplement the text with elaborate explanations. Many problems are given covering mining, civil, mechanical and electrical engineering. Photographs of string models are an interesting feature of the book. These models were made by Oliver of Paris and are part of a collection in the possession of the Department of Engineering Drafting of Columbia University.

Mr. Svensen is Professor of Engineering Drawing at the Texas Technological College and his book is intended as a text for colleges and technical schools, although its use is by no means confined to such institutions. Its study may be pursued by any of the recognized good methods.

Beginning with the fundamental principles of drafting, a description of the instruments and materials used, the book proceeds with chapters on engineering lettering, engineering geometry, orthographic projection, theory of dimensioning, bolts and screws, to working drawings. After engineering sketching there are chapters on the development of surfaces, detail drafting, computation of weights from drawing, pipe drafting and architectural, structural and electrical drafting. At the end of the volume is a chapter on technical illustrations and data which is of particular value to engineers in the writing of reports and compilation of technical papers.

STANDARDS OF THE HYDRAULIC SOCIETY, fourth edition, has just been issued as an 80-page, letter-size booklet, which contains sections on definitions and values, pump test codes and so on, and discusses various types of pumps. Many data tables, curves and formulas useful to the engineers are included. This may be obtained for fifty cents from the Secretary, C. H. Rohrbach, 90 West St., New York City.

ENGBERG'S ELECTRIC & MECHANICAL WORKS, St. Joseph, Mich., in catalog No. 303 just issued, describes in detail its vertical self-oiling, enclosed, piston-valve engines. Detailed drawings and tables of dimensions are given, together with illustrations of applications of these engines to various services.

LINK-BELT CO., 910 S. Michigan Ave., Chicago, Ill., in bulletin B-3, describes and illustrates Link-Belt "Clean Water" Intake Screens.

THE ESTERLINE-ANGUS CO., P. O. Box 596, Indianapolis, Ind., in a four-page leaflet discusses the advantages of using Esterline-Angus graphic instruments for process inspection in industry.

SERVICE which Ingersoll-Rand portable air compressors can render in excavation, construction and repair work is described and illustrated in a bulletin received from Ingersoll-Rand Co., 11 Broadway, New York.

CHAIN BELT CO., Milwaukee, Wis., has issued a new bulletin, No. 220, describing Rex chains and transmission equipment. This is supplementary to general catalog No. 210. Several new types of chains, sprockets, and other items are described. Revised list prices, chain weights and dimensions are also given.